NORTHWEST SCIENCE

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Vol. VI Number 1

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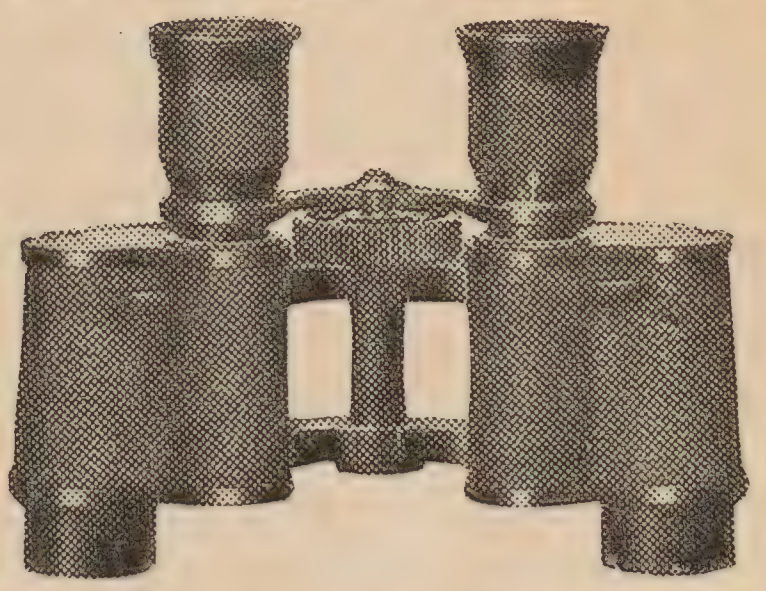

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THE SECRETARY, BROOKLYN BOTANIC GARDEN

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NORTHWEST SCIENCE

Entered as second class matter April 5, 1927, at the Post-Office at Cheney, Washington. Office of Publication, Cheney, Wash.

Published quarterly at a subscription price of $1.00 per year, which includes the membership dues of the Association. Non members $1.00 per year. Vols. I (1927), II (1928), III (1929), IV (1930), V (1931), complete, each $1.25.

Reprints of articles appearing in regular issues will be furnished to the author at the following rates, *provided they are ordered prior to the time of going to press.*

Pages	2	4	8	12
100 copies without cover	$2.50	3.00	5.45	5.95
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200 copies without cover	3.25	4.25	5.75	7.90
200 copies with cover		5.50	7.00	9.15
300 copies without cover	3.75	4.50	7.00	10.00
300 copies with cover		6.25	8.75	11.75

Printing of plates extra, at actual cost

NORTHWEST SCIENCE

A scientific journal published quarterly by the Northwest Scientific Association and devoted to the dissemination and promulgation of scientific effort in the Pacific Northwest.

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NORTHWEST SCIENCE

VOL. VI MARCH, 1932 NO. 1

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EDITORIAL

The Northwest Scientific Association has just completed a most successful year by recording for its eighth annual meeting the best attendance it has ever had. In addition, the Treasurer's report shows an encouraging and healthful condition of finances which speaks for itself in these times.

With a total attendance of more than 150, at our last annual meeting; with each section showing a steady increase in membership; and, with the renewed interest shown by the attendance of Oregon members we can well look forward to the new year with hope and encouragement.

At such a time when progress is being made by our Association in the face of unusual economic conditions, it is well for us to guard against the all-too-common tendency to rest on the oars. Bracing our feet and bending our backs to the task should be our self imposed obligation for 1932. The Association and the benefits we derive from it are worthy of our best efforts. We should, therefore, join whole heartedly with the Association officers in carrying out any plans adopted for the improvement of the organization and the promulgation of scientific effort in the Northwest.

In looking back over the eight years during which the Association has been active, the names of several men who have contributed unselfishly to its development appear prominently. Among these there is one member who may be mentioned specifically on account of the year-round, unstinting service he has rendered the Association for the past years, and that is Professor J. W. Hungate, our Secretary-Treasurer. Upon him rests the burden of administering the many details of our Association, the stimulation and direction of section leaders, the preparation of the annual program, mailing of the journal and the recording of financial data. To him, the Association owes a sincere appreciation of his helpful work.

Since it is planned this year to increase the circulation of Northwest Science, enlarge the issues and publish a geology number in June, it is requested that manuscripts and science news items be submitted as early as possible.

Research and the Teacher[1]

By
FRANCIS A. THOMSON
Montana School of Mines

MANY years ago when I was still so young an engineer as to be surprised at myself when I made a mistake, I had the privilege of being associated with one of the most intelligent men I have ever known. This man Bartolomeo Bracco by name, and familiarly known as "Bat," was of course an Italian. Whether he could read or write Italian I never knew, nor did I have the sense at the time to ascertain, but so far as English was concerned he was illiterate, so much so that he would bring to me letters from his married daughter and under the pretext that he had forgotten his glasses or some other lame excuse, would ask me to read the letter and indite a suitable reply. But in his field, the erection and repair of smelter machinery, Bat was an artist. When we would have a breakdown in the plant Bat—the master mechanic—always knew how to make the repair. Sometimes I would question his method of procedure, invariably he would reply, "Ha! Mr. Thomson I make experimentry, *I know.*" Like his illustrious countryman Galileo, to whom modern science owes so much, old Bat, had the truly scientific spirit, his one classic remark "I make experimentry, *I know*" has rung in my ears a thousand times, and with the perspective of middle age I have come to regard him as one of my most significant teachers, because he emphasized in my young mind that the path to knowledge is through experiment.

1. Retiring Presidential Address Before the Northwest Scientific Association at Spokane, Washington, December 29, 1931.

And this brings me to my topic, "Research and the Teacher."

In spite of all the advances which have been made through scientific research, or possibly even because of them, there exists, it seems to me, in the mind of the man in the street, in the minds of college administrative boards, and even in the minds of those unfortunate college professors who have become egregious oligarch rejoicing in the title of president, a tendency to think of research as external to teaching.

Now the function of a college or university in the words of A. N. Whitehead is "the imaginative acquisition of knowledge," the preservation "of the connection between knowledge and the zest of life," furthermore no college worthy of the name should be content to be entirely a second-hand store handing down to the eager youth for whose development it exists, the knowledge accumulated by others beyond its walls—surely, the college as a part of its contribution to society is under a sacred obligation to add something new to the sum of knowledge.

Viewed thus, then, the college must in some measure discharge the dual function of discovering and diffusing knowledge, and it must maintain a careful balance between the search for new truth and the dissemination of old truth among its students.

Obviously, the college may do this in one of two ways. First, by having a teaching staff to do the teaching, and a research staff to do the researching. Second, by blending the two so that every man on the college faculty

is expected to spend a certain portion of his time in each field.

I am well aware that many distinguished educators, among them my good friend the president of this society, believe that there is an inherent antagonism between teaching and research especially in the case of undergraduate teaching, and I am not unacquainted with the old story of the man wrapped-up in his research who says "what wonderful places these colleges would be if only we could get rid of the students." Nevertheless, it is my observation that the most uninspiring teachers in the colleges I have known are not the research men, but those individuals who completed their graduate work 10, 20, or 30 years ago, and who have rested on their oars ever since, feeling that the halo of their doctorate shed a sufficiently intellectual emanation to excuse them from any further exercise of their wits. In the recent words of Hans Zissner there is no longer room for those to whom the act of instructing is a mechanical thing or for those who are content to shuck down to the waiting herd the dry hay of old harvests.

It is therefore of research, as a vitalizing force in the intellectual lives of instructors and students alike, that I desire to speak this evening.

Of the justification for research both in pure science, in applied science, and in every other field of knowledge it would be like bringing "coals to Newcastle" to undertake a discussion before a scientific association such as this, but I am inclined to think that nearly all those members of this society,—comprising two-thirds of its total roster—who are connected with teaching, will agree with me when I say that the most vital teaching they have ever done has been when they have been able to lead their students to the point where the students discovered something for themselves. This is of course the adventure of scholarship.

All of us complain of the lack of interest on the part of our students. It is not possible that the fault lies with the system rather than with the student? The intelligent little child is a human question mark, somewhere along the way this surpassingly intelligent attitude of asking question upon question upon question, disappears in all but a few of the most intelligent of us—What has killed it? And what can we who are in college work do to bring it back to life? In this sense it is as true in the field of learning as in the field of religion, "Except ye become as little children ye shall in no wise enter into the kingdom of heaven."

You will recall that the late great Edison, (whose methods of research left some things to be desired) nevertheless hit the core of the matter when he said, "We keep on asking nature questions, and asking her questions and finally she says "Uh-uh." This reminds me of a recent rendering of the old verse which we all earned as youngsters:

"So near is beauty to the dust,
So near is God to man
That when stern duty says thou must,
The youth replies, "I can."

The modern version goes we are told thuswise:

"So near is beauty to the dust,
So near is God to man
That when stern duty says thou must,
The youth replies, "Oh Yeah!"

And by the way, I think that this eloquent vulgarism "Oh Yeah" is the typical youthful response to the doctrine of authoritarianism. But no youth however blase he might desire to ap-

pear, ever said "Oh Yeah" to a new and interesting discovery in science or scholarship which he had made for himself. And I believe that in the research method of teaching so far as it can be aplied lies the answer to much of the criticism of lack of interest on the part of the student.

In 1918, C. R. Mann made a study of engineering education for the Carnegie Foundation, and speaking of the teaching of physics he said, "The methods and aims defined by Professor Pickering in 1869 are still dominant everywhere. About one-third of his original experiments are still in use and the new ones that have been introduced have as their objects the verification of some known law, the visualization of some known fact, or the determination of some known constant." I wonder how far we have progressed in laboratory instruction in physics and in other fields of science since Mann wrote his criticism.

Obviously I suppose there must be a certain amount of routine drill in certain fundamentals but if we are to enlist the avid interest of keen young men and women we must introduce them as early as possible—and I believe it can be done much earlier than is generally admitted—to the research method. The zest of discovery must be brought back. This is being done in some fields. Gerard at Chicago has done it in physiology with conspicuous success in a freshman class. Others are using it, but all too few. Possibly only those instructors, who are themselves engaged in research are likely to make a success of such a method.

Research men are sometimes thought of as being cold and analytical and incapable of imparting information to others, but the best research men I know in my own or allied fields are keen, clever and imaginative. Indeed, I would venture the assertion that no great piece of research work was ever done by anyone who did not possess a brilliant and fertile imagination. An imagination capable of formulating a brilliant hypothesis upon the evidence accumulated and keen enough to submit this hypothesis to further attack by himself and his colleagues in his field.

And it is this type of man who is needed to cope with the "Oh Yeah" boys and girls in our colleges and to fire their imaginations to the kindling point. To insulate the undergraduate student from contact with the research work of a college is to fail to use the most effetive means of education at our disposal.

To say that men of the imaginative research type should come in contact with none but graduate students is, in my judgment, to sterilize the atmosphere of undergraduate teaching.

And this applies to instructor and student alike for in any college situation it is impossible to separate the two—one is the complement of the other.

A short time ago I was asked to prepare a statement expressive of my own attitude with respect to research in our institution. This statement was published in an article devoted to a description of the development of a new copper alloy by a member of our faculty, who is a brilliant research metallurgist and at the same time one of the best teachers on our campus.

With your permission I should like to read this to you as the credo of our little college.

"Research is the life blood of any educational institution. Without it, instructors face intellectual starvation and intellectual death. Nothing is more deadening than to teach, teach, teach, day in and day out without the mental stimulus of experiment and discov-

ery. Out of such a situation, devoid of research, grows either that overwhelming conceit which makes the teacher intolerable, or an inferiority complex which makes the teacher the fulfilment of Bernard Shaw's sarcastic comment 'that those who can, do, and those who can't, teach.' And a college teacher in science or technology, must DO, or he becomes, in my judgment, a hopeless futilitarian.

"The implications of this with respect to the student body are perfectly obvious. A stream can rise no higher than its source, and although here and there a student may be found who will outstrip his mentor in intellectual accomplishment, neither the undergraduate nor the graduate student is likely to exceed the stimulus afforded by his major professor. A stimulating instructor begets a stimulated student; Professor Dryasdust may be a nice old chap whom everyone likes, but he fires the imagination of no student. Whitehead defines the function of a university as 'the imaginative consideration of learning' and in the Montana School of Mines we are endeavoring to put Whitehead's definition into effect with 'imaginative' written in bold-face type. In scientific work imagination is both the cause and the result of research. Thus we are finding it is impossible to confine the research spirit to faculty and graduate students, and as a consequence our undergraduates are beginning to demand the opportunity of doing something, on their own responsibility which of course is the ultimate purpose of our type of education.

"In industry we find the great corporations everywhere developing research organizations and looking to the college faculties for men to direct and carry out their programs of investigation. Roger Babson lists support of research as one of the four great essentials of business revival, and in this he is merely recognizing what eve y progressive enterprise already knows, that like the technical college it must either engage in research or die."

Perhaps we are wrong; if so events will prove it. Whether the same doctrine applies outside the field of science pure and applied I do not presume to state, but I suspect it does.

It may be urged that research men who can teach are rare. In reply I would like to say, that good teachers are always rare and probably always will be, but it is my opinion that no man devoid of the instinct for research and no man denied the opportunity to practice it, can possibly be a good teacher for any but the most ordinary minds. As President Morgan of Antioch college puts it:

"Teaching without research is but indoctrination. Lacking a spirit of inquiry one cannot transmit it. Conversely research without teaching fails to transmit its ardor, insight and skill. The research man who does not teach has no spiritual children."

Now let me turn to another phase of the question. There has grown up in the last few months, I understand, in certain college administrative circles a tendency to diminish research programs, or at least to caution college faculties to avoid public discussion of research programs because it is alleged in some quarters that scientific research has brought us to our present economic pass.

Such an attitude, it seems to me, is not only utterly unjustified by the facts, but is one which if it became general would emasculate and seal the doom of very college and university and reduce it to the level of a grade school.

In the first place the assertion that the contribution which science has made to the extractive industries, agriculture, forestry, and mineral indus-

try, are responsible for the present over-production, is one of those half-truths which are worse than lies. Applied science has, in response to the demands of industry, shown the farmer, the lumberman, and the miner how to produce more and better goods per unit of operation than has ever before been possible, and at a lower per unit cost.

But the responsibility for the misuse of this information lies not at the door of the scientist, but upon those who ignoring the plain dictates of science's twin-sister economics, have in their blindness over-expanded their operations beyond the normal ability of their markets to consume their products. It is upon the captains of industry and the leaders in agriculture that the blame if any must be placed and not upon the scientists, most of whom have labored from the sheer love of their work and with no such expectation of monetary reward as has misled those who have misapplied the results of scientific research.

What is needed at this time more than ever before is more research and more training of recruits for the field of research, in order that we may in the future more successfully avoid such pitfalls as that in which we are now entrapped.

And so in closing I would say to my fellow-members of the Northwest Scientific Association, "Carry On." Continue the great work in which you are engaged for upon you and upon others like you and upon those whom you must train to succeed you; rests the security of our civilization. It is unthinkable that we are to begin at this late date, as advocated by Mahatma Gandhi, to revert to the primitive methods of our forefathers. "Science, science, and more science; research, research and more research," must be our battle cry, for that way lies the salvation of the human race.

And finally let us resolve that the Northwest Scientific Society will stand firmly and unflinchingly for the wedding and not for the divorce of research and the teacher.

HOW WEATHER CAUSES TREE DISEASES

When crops are poor, when epidemics of human disease are prevalent, or when forest fires rage over a wide territory, we are constantly reminded "it's the weather". The weather appears to be held responsible for many things including rheumatism, high fuel bills and the irregularities in the yearly growth of trees. Now come the forest pathologists to fill the cup to overflowing by stating that weather conditions are responsible for a considerable number of important tree diseases.

Trees are often subject to sunscald and drouth, and a peculiar type of injury called "red belt" is frequently observed affecting conifers in the Pacific Northwest. Following a winter of rapid and severe changes in temperature a wide belt of trees is observed turning a bright reddish brown color and the discolored needles soon drop off. This is, at first, quite alarming. However, most of the trees recover unless the buds have been injured. Sunscald of shade trees is very common on many of our maples growing in yards and in parkings.

Frost causes several types of injury in trees and too much heat produces another group of diseases. Wind and lightning play interesting parts in producing peculiar diseases in trees and snow encourages the development of diseases on seedlings and branches buried under its drifts. Too much rain causes root suffocation, excessive dust produces a harmful disease of the leaves, and gases, such as smoke and smelter fumes, produce under favorable weather conditions very striking symptoms in forest trees resulting at times in very severe losses.

A tree may be frozen solid during the wintertime and yet show no affects the following spring but if certain conditions of the weather favoring rapid thawing are present then the tree suffers. It is the rate of thawing, apparently, which determines whether freezing injures the tree, much as the manner of thawing a frozen hand determines whether or not permanent injury may follow.

—E. E. Hubert

Case Hardening of Steel by the Nitriding Process[1]

By
T. ERHARDT BOEHME
State College of Washington, Pullman, Washington

NITRIDING is the process of producing an extremely hard case upon nitralloy steels. As a commercial process it is in its infancy, but it is a healthy infant and one no user of metals who is worried about the problem of wear resistance can afford to ignore.

We are indebted to Dr. Adolf Fry of the Krupp Works, Essen, Genmany for the invention and practicability of this new process. Following his original discoveries many investigations have been carried on, but there is still room for considerable research.

A nitride case is formed by heating a special steel in an atmosphere of ammonia gas at a temperature varying from 850-1200 degrees Fahrenheit, the temperatures most used being between 950-1000 degrees.

Ordinary case hardening on the other hand requires prolonged heating at a temperautre of 1600 degrees Fahrenheit followed by quenching. The sudden cooling induces internal strains which as a rule badly warp the article case handened. In fact one can never be sure that warpage does not occur and this is usually provided for by machining oversize and grinding after heat treatment.

The steel ordinarily used for case hardening is of low carbon content incapable of being heat treated to any large degree of hardness. A low carbon steel is used when a soft core is desired. If a high carbon steel is used, quenching from 1600 degrees leaves the core in a very hard condition. Any attempts to draw part of this hardness by subsequent heating will destroy the case.

Nitralloy steel may be heat treated to any degree of hardness between the critical temperature of the steel and the nitriding strength. Since a semi-plastic state is not reached there is no danger of warpage from this source. No quenching is required after nitriding so warping is entirely eliminated.

There is a growth in size of the hardened part as a result of nitriding. This growth is from .001-.002 inches. It is constant for any given set of conditions and is offset by machining under size.

Since no oxidation takes place in the furnace the work may be finished completely before nitriding.

The amonia gas goes through some interesting changes from the time it leaves its container until it is expelled from the nitriding furnace. First it goes through a drying tower which contains calcium oxide. This removes all moisture. From here it is conducted into the furnace through nickel tubing. When the ammonia comes in contact with the hot nitriding steels, which are placed on nickel gauze or nickel chromium screen, it partly dissociates into nitrogen and hydrogen. The hydrogen is inert but the nascent nitrogen unites with the iron in the steel to form various iron nitrides. The undissociated ammonia, the hydrogen, and some of the nitrogen is then expelled from the furnace into a stream of running water.

1. Presented at the annual meeting of the Northwest Scientific Association, December 29-30, 1931, Spokane, Washington.

The per cent of dissociation of the ammonia is measured by a special measuring apparatus. The dissociation should be above 20 per cent. This value is an indication of the reaction but does not, in itself, mean much unless it is thought of as a function of flow and temperature.

The iron nitrides formed on the surface of the steels do not impart harmful brittleness as is common in other steels. Exactly why a nitride case is hard is not known. A number of theories have been advanced by authorities on the subject, but they will not be discussed in this short paper.

A nitrided surface is the hardest ever produced on any metal. It is significant that new hardness testers had to be developed especially for use with these steels. Diamond is the hardest known substance having a Brinell hardness of about 1300. Nitride cases run a close sceond with hardnesses ranging from 950 to 1000 Vickers Brinell. The hardest tempered tool steel is 650 to 700 Brinell, and ordinary cases run from 600-650 Brinell.

A diamond point on a Brinell testing machine will break through the case into the soft core below. If the case is too deep and the core quite hard the diamond point will break. A nitride case, therefore, must be tested by one of the special machines mentioned and transferred to the Brinell scale.

There are three factors which influence hardness and depth of case. These are: Time, temperature, and rate of flow of ammonia. The depth of case is a functoin of time, but not a straight line function. The rate of penetration gradually decreases after twenty-four hours. It is not considered economical to nitride over seventy-two hours.

The effect of temperature is twofold; namely, upon the surface hardness and upon the hardness gradient within the case. The hardness drops rapidly with a decrease in temperature.

The rate at which ammonia is introduced into the furnace influences the hardness of the charge. The degree of dissociation varies with the rate of flow, the temperature and the area of the heated surfaces in contact with the gas. The distribution of the available ammonia among the charge is important if uniform work is to be obtained. This is done in some standard furnaces by a fan which reverses automatically every minute. The distribution of the gas is further facilitated by the reversal of the direction of flow in the inlet and outlet tubes with the reversal of the fan.

In order to carry out nitriding successfully it must be done in a container, or furnace, the surfaces of which will not nitride because the iron nitride is a catalytic agent which increases the dissociation of the ammonia gas. The process then requires as the furnaces ages, a greater flow of ammonia to produce the same result. This has been largely overcome by the choice of materials which are very slightly affected, if any, by ammonia at nitriding temperaturse. The furnace linings which have been found most successful are comparatively few in number. They are porcelain enamel, brick, and a high nickel chromium alloy. Tests of various enameled carbon steel and iron containers have been found to be excellent at 950-1000 degrees Fahrenheit.

At Washington State college the nitriding process has been carried out using an enameled cast iron box. Some difficulty was met with in the preparation and application of the porcelain enamels because a method of procedure had to be devised. We are now working on the design of a controlled atmosphere furnace which may be used

for hydrogen brazing, nitriding, and general heat treating as part of our laboratory equipment.

Nitrided parts may be used where resistance to wear at both high and low temperatures is a fcator. In the automotive industry nitride steels have been used for all manner of engine parts.

Nitrided cylinder walls have been used in the Hispano-Suiza automobile engine. These showed unusually low wear in service. Guillet has studied the wear resistance of nitrided steel and cast iron cylinders after 18,600 miles of travel finding .016 inch wear on cast iron and .0008 inch wear on the nitrided cylinders. On aviation motors he found that heat treated steel cylinders were .003-.004 inches while on nitrided cylinders the wear was not measurable.

Nitrided intake and exhaust valves used with gasoline containing tetraethyl lead have performed unsatisfactorily.

Bearing friction tests, in which nitrided steel was tested without lubrication at high temperatures against nitrided steel, bronze, or cast iron, show promising possibilities.

The Firth-Sterling Steel Company recommends nitrided steels for ball and roller bearings, ball cones and races, coining dies, gauges and blast nozzles.

There are seventeen special nitralloy steels containing various proportions of carbon, aluminum, chromium, molybdenum and vanadium. Aluminum and chromium contribute to extreme hardness while molybdenum and vanadium increase the toughness and depth of penetration. The choice of a steel would depend on its use.

Every manufacturer is interested in costs. The cost of the process itself is low. One company reported a cost of 1.5-3.5 cents per pound for 24-60 hours of nitriding respectively. This however is an exceptionally low figure. Another company finds the cost ranges from 4 to 50 cents per pound.

In this process as in many others the first cost is the greatest. The equipment is expensive and the cost of nitriding steels is rather high, but it is to be hoped that increased production and demand for nitrided parts will bring the cost of steel and equipment down to the point where the benefits of this new process may be enjoyed by the small jobber and manufacturer as well as the large concerns.

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Some Observations on Lichens As Factors in Northern Rocky Mountain Forest Succession[1]

By
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LICHENS play an indirect part, not often recognized, in the life history of the coniferous forest formations and successions of the northern Rocky Mountain region. Their influence has probably been little observed because it is exercised chiefly through the medium of forest fires. The part played by fire is spectacular and obvious and has long been recognized by foresters and others. The humble lichens are an inconspicuous group of plants which attract the attention of but few and they are commonly waved aside as "moss" or "tree moss" by those who know them casually.

In the recent past, and probably in the much more distant past, fire due to natural causes has probably been the chief agency in this region by means of which nature removed decadent stands of trees, sub-climax and climax vegetative formations, and prepared the ground for a fresh and more primitive stage in plant succession. The earliest written reference the writer has seen in regard to forest fires was made by Lewis and Clark[2] in their Journal, on September 15, 1805, when they were traversing the historic Lolo Trail in what is now the Clearwater National Forest in northern Idaho.

There are only three species of lichens among the many found here which exert a clearly evident influence in the life history of the forest vegetation of the region. They are: *Alectoria fremontii,* commonly called "black moss" or "squaw-hair moss" by local woodsmen; *Alectoria sarmentosa,* often called "green moss"; and *Letharia vulpina* (syn. *Evernia vulpina*) which is probably identical with the "Ulf mossa" or "wolf moss" of old folk tales of some of the German and Scandinavian people. Other species which clearly sometimes play a minor role in the advanced stages of tree succession are *Parmelia* (*vittata* ?) and *Lobaria pulmonaria.* Identifications on all of the above species except *P. vittata* ? were made by Mr. G. K. Merrill, since deceased, on material collected in northern Idaho by the writer. Mr. Merill was recommended by the Smithsonian Institution as authority on the identification of lichen material.

The three species first named above grow in great quantities on the twigs, branches and trunks of the mature and decadent trees of the vast coniferous forests of the region. They are finely divided, fruticose lichens, extremely sensitive to changes in atmospheric humidity and highly inflammable during the periods of extreme dry weather that characterize the summers of this region. They are usually by far the most readily ignited fuel to be found in the forests and are wonderfully suited to the transmission of fire to more substantial fuels, to carry it from the ground up the clean boles of tall trees, and to aid its rapid spread from one tree to another.

The *Alectorias* appear to contain a small amount of an oily or resinous

1. Presented at the annual meeting of the Northwest Scientific Association, December 29-30, 1931, Spokane, Washington.
2. Thwaites, Rueben Gold. Original journals of the Lewis & Clark expedition. Vol. 3.

substance which permits them to burn freely even when quite damp. In addition, their more or less net-like form catches and holds bits of resin that fall or drip from the trees, dead leaves in considerable quantities and bits of dead twigs. These materials provide heavier fuel well suited to generate sufficient heat to ignite the lichens' substratum of bark or dead wood and, given a bit of wind, a conflagration is quicklv started and spread.

Another important peculiarity of these lichens is the facility with which burning portions of them become detached from their substrata and are wafted on even a gentle wind of ten miles per hour or less, to distances of 50 or 100 feet or more where they ignite other lichens and thus serve to carry the fire rapidly forward in the crowns of the trees. In the draft of a conflagration fragments of the *Alectorias,* both burning and unignited, are often carried aloft in considerable quantities. The unignited pieces may ascend in the smoke column for hundreds or for several thousand feet and may fall unburned at long distances from the fire. Incidentally, this may be a moderately effective means of wide distribution of vegetative germules.

These *Alectorias* are slow growing, long-lived plants which become established very slowly and, therefore, play little or no part in the destruction by fire of young trees under 50 or 60 years of age. They commonly give the old trees their aspect of bearded and hoary old age and one or both species are almost universally present in quantities on all species of conifers in the region after they reach an age of a century or more.

It is well known to foresters that lightning not infrequently ignites the lichens in the crowns of an over-mature stand with the result that a crown fire, the most difficult sort of fire to control, develops immediately and, given a little wind, spreads with great rapidity. The writer well recalls two such fires which started in July, 1924, in the Clearwater Forest in stands of over-mature *Tsuga Mertensiana.* Both of these fires spread immediately and quickly reached areas of about 35 and 65 acres respectively in spite of the fact that ground beneath was so damp and the cover of *Vaccinium* and *Menziesia* so green that but little of the ground cover and forest floor was burned over, although nearly all of the trees were killed outright. The smaller of these fires stopped in full career along the edge of a stand of *Tsuga Mertensiana* which was estimated to be 80 to 100 years of age and which was practically devoid of fruticose lichens.

Because it is less finely divided, somewhat less inflammable, and usually present in smaller volume, *Letharia vulpina* is less important as a fire factor than are the *Alectorias,* nevertheless, it is often decidedly important in subalpine stands of *Abies lasiocarpa* and *Pinus albicaulis* where it is often the only lichen present in substantial quantity. This is also sometimes the case in forests of *Pseudotsuga taxifolia* on dry sites. In most such cases it forms a dense growth on trunks and the larger limbs and its principal rôle is to provide a flash fuel which carries a surface fire upward into the crowns where it kills the tree and from whence it may spread rapidly to neighboring tree crowns.

Lobaria pulmonaria is found in this region only at moderate elevations, perhaps up to 4,000 feet above sea level and only in moist sites. It is occasionally a moderately important fuel in carrying fire upward into the crowns of *Thuya plicata, Picea Engelmanni* and, less frequently, in *Populus trichocarpa.*

Other lichens, such as the *Peltigeras* and *Cladonias* contribute a relatively small amount to the sum total of fuel on the floor of most local coniferous forest formations, but have only a very minor part in the removal of formations by fire.

It is, of course, wholly impossible to state what proportion or any burned area is due to the influence of lichens. It is well known to observant foresters and woodsmen that the presence of lichens or "tree moss," as they call it, greatly encourages the spread of forest fires.

Thus the lichens, it appears, play an important rôle in bringing about the removal of closed coniferous forest formations in the northern Rocky Mountain region, most often in either climax or preclimax forests, opening the way for a new plant succession which usually begins with shrubs and herbaceous species, particularly *Chamaenerion angustifolium,* the common "fire weed" of the region. Depending on the severity of the burn, the new succession may start with liverworts and mosses, and, in some cases, crustose lichens are a moderatly prominent feature in it, particularly on very poor soil.

Some Facts About Fuelwood

The encouragement in the use of wood as fuel has resulted in a new interest regarding the value of fuelwoods. Many people wish to know the relative values of wood fuel as compared with an equal weight of coal. In general, two pounds of dry wood give off as much heat as one pound of good coal, and one cord of the heavier woods such as maple, hickory, and cherry is equal in heat value to one ton of coal. Of the lighter woods such as cedar, cottonwood, spruce, and basswood, it requires about two cords to equal the heating value of one ton of coal.

The weights of various woods per given volume give a good indication of their relative values for fuel, but equal weights of those woods containing no resin give about the same amount of heat when burned. The average heating value of *dry* wood is about 8030 British thermal units (B. t. u.) per pound, and for ordinary coal about 12040 B. t. u. per pound.

Douglas fir, western larch, and ponderosa pint (commonly known as western yellow pine, bull pine, etc.) are good fuel woods, giving off intense heat, but each one varies in qualities such as ignition, uniform heating, and rapid burning.

The pines, such as ponderosa pine, burn more rapidly, but give a quicker, hotter fire, while woods like Douglas fir and larch burn slower and hold fire longer. Woods containing resin or oil burn in proportion to the amount of oil or resin—dense pines containing 30 per cent of resin, for example, have a relative fuel value considerably above that of hickory.

In judging the fuel values of various woods the moisture content of the wood, its density and the amount of resins or oils it contains, and the special purpose for which the heat is required should all be carefully considered.

Allowing 80 cu. ft. to an average cord, the following are the average weights of a cord of: heavy wood—4,000 lbs., medium wood—3,000 lbs., light wood—2,000 lbs. The relative fuel values of various woods per unit volume of dry wood are as follows: Hickories, average 100, birch 87, maple 87, ponderosa pine (10% resin) 84, mountain ash 80, larch 76, Douglas fir 65, western hemlock 61, lodgepole pine 58, white pine 56, white fir 55, spruce 52, Alpine fir 48.

—*E. E. Hubert*

The Influence of Climate on Washington Agriculture[1]

By

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AMONG the several potent influences on the agriculture of any region, including type of soil, topography, population, markets, and climate, the last is one of major importance. In his book "The Farm"[3] Eugene Davenport says, "That combination of heat, light and moisture which we call the climate is exceedingly variable, but it is a controlling factor in crop production everywhere. It is the climate even more than the soil which decides what crops shall be grown, and the agriculture of any region must be adjusted to its climatic conditions. * * * * Climate provides natural conditions that are ideal in some sections while it creates impossible barriers in others, against which it is useless to contend."

Through careful observation and study of the influence of climate on agriculture certain principles expressing this relationship have been formulated. In "Farm, Soil, and Improvement"[4] by Sir John Russell these are expressed as follows: (1) Dry climates favor seed and grain formation and are also suitable for sheep. (2) Moist climates favor leaf formation; they also favor bullocks and dairy cattle. (3) Wet climates suit grasses. (4) Warm early regions suit market gardens and special crops." Although our Washington agriculture does not conform fully to these principles, in the main they apply.

Those of us who have lived in Washington for any length of time and have had opportunity to study its climate by records, travel, and observation appreciate its great variety. While it is generally known that climate changes gradually with the latitude and that spring and fall are advanced or delayed a week or so, as the case may be, for every 50 to 60 miles south or north, other factors which greatly influence climate are not equally well known. For the inexperienced it is difficult to realize that within a radius of a few miles one may change because of differences in altitude from the perpetual snows of winter to the moderate temperatures and vegetation of spring and summer, or from abundant precipitation and heavy vegetation to areas of extremely limited rainfall and a desert flora. Nor is it easy for the uninitiated to understand how the oceans, the mountains, the rolling hills and the abrupt or gentle valleys transform the solar climate into a physical climate of great variety, so that sections at no great distance from each other may vary greatly in rainfall and snows, in humidity and temperature, and in wind direction and velocity. These factors, which combined constitute climate, have a large influence, often a predominating one, on the type of agriculture in the different sections of Washington.

Broadly speaking, Washington may be said to fall within two climatic zones: one west of the Cascades, tem-

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1. Presented at the annual meeting of the Northwest Scientific Association, December 29-30, 1931, Spokane, Washington.
2. Acknowledgment is made herewith to members of the staff of the College of Agriculture and Experiment Station of the State College of Washington for valuable assistance in connection with assembling the material for this paper.
3. Rural Science Series, MacMillan Company, 1927.
4. London, 1923.

pered by the ocean and characterized by a high humidity, abundant precipitation during the fall, winter and spring, and a comparatively small variation in temperature; and another east of the Cascades with less rainfall and greater extremes in temperature. Again these two zones may be subdivided into the strictly coastal area of southwest and western Washington with a precipitation of 60 to 138 inches* per year, the Puget Sound country with 21 to 55 inches, and the western slopes of the Cascades with 55 to 100 inches per year; central Washington with less humidity and precipitation on the eastern slopes of the Cascades merging gradually into areas of less and less rainfall towards the Columbia and Snake rivers where at an altitude of 600 to 700 feet only six or seven inches are received, then gradually increasing again in precipitation towards the higher altitudes in the eastern part of the state until on the more elevated plateaus and near the mountains at an altitude of 2,000 to 2,700 feet, there is a rainfall of 13 to 25 inches.

Again in western Washington because of the proximity of the ocean and prevailing winds from the southwest, the mean temperature in the Puget Sound country ranges from 38° in midwinter to 62° in midsummer, and near the coast 40° in winter and 60° in summer. In the Sound region the daily range is from 33° to 43° in winter and 50° to 74° in summer with frequently a difference of only 5° in day and night temperautres in winter, but sometimes as much as 30° to 40° in summer. Hot or cold spells are very rare in this region. The lowest recorded temperatures only at long intervals will reach zero or below, while the summer temperatures rarely rise above 90°. The growing season is long, the average period between killing frosts in the Puget Sound region being 200 days. Here and there, as on Whidby Island, there is a growing period of 240 to 250 days. In the lower Columbia Valley it is 208 days and in the Chehalis-Grays Harbor district, about 185 days.

In eastern Washington, on the other hand, temperatures are more extreme, ranging at times from lows of 26° to 30° below zero in the northeast in winter, to a high of 105° to 116° occasionally during the summer in the Walla Walla, Yakima and Snake River valleys. These extremes are rare, however, and the whole region, though characterized by colder winter and warmer summer than western Washington, nevertheless has climate which permits of abundant crop production wherever precipitation is sufficient or can be supplemented by artificial irrigation. Moreover, the growing season, although shorter in the main than that of western Washington, ranges from 173 to 241 days in the Chelan country, 71 to 165 days in the Colville country, and 176 to 273 days in the Walla Walla country, a period long enough to mature cereals and grasses in the shorter season areas, and tree fruits, bush fruits, vegetables and truck crops of all kinds in the areas where the frost-free period is longer.

With such striking dissimilarities in climate in the different sections of Washington it is clear that even if the soil and other factors were identical, there would be a large variation in natural vegetation and in the variety of well adapted cultivated crops. This is accentuated by the differences in soils occasioned not only by the variety of the rocks from which they were derived, but by the differences in climate during the period of soil formation. The soil no longer is regarded merely

*. The specific data on climate in this paper are from the reports of the U. S. Weather Bureau.

as the product of rock disintegration. It is now understood to be also a product of the forces of climate, possessing qualities not necessarily related to the geological characteristics of the parent rock. Indeed, two distinctly different rock formations may yield strikingly similar soils and similar rocks different soils, when the weathering forces have completed their work. Some of the outstanding differences in soils are due to differences in the climatic forces to which they have been subjected over long periods of time, and local differences often are due to climatic variations which either have halted or delayed natural weathering processes.

In the two distinct climatic zones of eastern and western Washington even a cursory examination reveals differences in soils of simliar texture and from similar rock formations. Thus a silt loam from western Washington contains .6 per cent of calcium, .09 per cent of phosphorus, and 1.2 per cent of potassium; while a silt loam from eastern Washington contains twice as much calcium or 1.21 per cent, considerably more phosphorus—.11 per cent, and more potassium—1.9 per cent. The heavy rainfall and more severe leaching and weathering on the west of the Cascades have reduced the quantity of plant nutrients in the soil, leaving an accumulation of iron and aluminum in the upper layers, and the lower rainfall with less leaching and weathering in eastern Washington has left the soil richer in plant nutrients and free from accumulations of iron and aluminum. In central Washington because of the very low precipitation, the plant growth on virgin soil is very limited and the soil organic matter content in virgin soil is correspondingly low. Broadly speaking, as a result of climatic factors more than of geological derivation, the soils of eastern Washington are more fertile than those of western Washington, with the exception that some of the valley soils of western Washington which have been built up from the richer soil elements washed down from the higher slopes, plateaus, and mountain sides, and which have not been subjected to severe weathering in situ, are very fertile. All of this has had a striking effect on the nature of the crops and the type of agriculture in the various regions.

Why grow so much cereals particularly wheat in eastern Washington, why not substitute grasses and other crops, are questions often pertinently raised in these days of economic difficulties of the wheat grower. One answer is climate. Wheat may be grown almost anywhere in the temperate zones of both hemispheres, but maximum yields, as in the case of other crops, are produced in regions where climatic conditions are most favorable. Winter wheat, for instance, prefers winters with considerable snow followed by a long, cool, moist spring and comparatively dry summer. As the crop matures, increasing dryness or aridity is desirable, and after it has blossomed very little or no rain is necessary until maturity, provided there is sufficient moisture reserve in the soil. Dry air and abundant sunshine are highly desirable for wheat during the later maturing period, while excessively hot, dry air as in the case of scorching winds during the heading and blossoming period may be disastrous to the crop. Large areas of good land in eastern Washington including the Walla Walla, Palouse and Spokane regions and part of the "Big Bend" have these climatic characteristics, and therefore are well adapted to winter wheat production. The Walla Walla and part of the Palouse country are especially favorable for wheat because of the moisture laden winds dur-

ing fall, winter and spring, which come up from the ocean through the Columbia river gap and spread out and deposit their load. In small portions of western Washington, such as Whidby Island, the cool, moist periods of fall, winter and spring and the dry summers also are ideal for winter wheat. What is believed to be the world's record yield of 117.5 bushels per acre on 18 measured acres, was grown here.

In the larger part of the semi-arid sections of the state native vegetation is limited to certain grasses and sage brush. When these are turned under or removed wheat and rye are grown because they are better adapted than other crops; thus they persist in spite of the hazards of the drouth and low prices.

In the United States and in Australia the wheat crop has been moving gradually from the regions of abundant rainfall to the areas of 25 inches or less. In our own state wheat is produced over large areas with a rainfall of 8 to 15 inches a year, under the alternate crop and summer fallow system. The same conditions that produce good winter wheat are favorable to the production of rye.

In certain sections of the Columbia River Basin, including parts of Lincoln, Adams, Douglas, Grant, and Franklin counties, the climate is better adapted to spring than to winter wheat. The low humidity and lack of snow covering in winter generally is fatal to fall-sown wheat in this area.

A fairly early cool spring with abundant moisture until towards the heading period of the crop is most desirable for spring wheat. Since spring often is late and early summer rains are not abundant in eastern Washington, spring wheat is less well adapted to areas where there is snowfall and comparatively abundant precipitation than is winter wheat.

Oats are not grown to any appreciable extent in eastern Washington primarily because of low humidity and comparatively high summer temperatures during the heading and maturing period. Cool, moist weather is particularly desirable when oats are heading. Certain portions of western Washington with its cool, moist winters and spring, and summer without high temperatures are better adapted to oats than is the wheat country of eastern Washington.

Climatic conditions in eastern Washington are favorable to barley. This is a short season crop requiring less high temperatures than corn, and since its feed value is similar to that of corn it is substituted for it here and there in eastern Washington. This crop is unusually well adapted to the higher altitudes with low summer temperatures. It cannot compete either with wheat or rye in the drier areas of the higher temperatures, or with corn in the warmer irrigated sections.

Corn is grown on 75 per cent of the farms of the United States, but in Washington it is found as a field crop only on a comparatively few farms and mostly in the irrigated sections. Corn requires a warm climate with plenty of moisture, warm days, and comparatively warm nights. Unirrigated eastern Washington has some of the warm days, but much of it is lacking in moisture, and where moisture is sufficient in the higher altitudes nights are too cold. To succeed well corn should be grown where there is an average daily minimum summer temperature exceeding 58° F., where there is a frostless season of not less than 140 days, where the mean summer temperature is between 70° and 80° F., and where there are 25 to 50 inches of water available, much of which should be available in July. Only parts of irrigated Washington, such

as the Yakima and Walla Walla sections, fulfill these requirements, but in these valleys corn will yield as well as in Iowa and may be grown to advantage.

Sunflowers may be substituted here and there for corn for ensilage since their adaptation to the drier and cooler parts of eastern Washington is better than that of corn. The optimum temperature for sunflowers is four degrees less than for corn, and they are less subject to injury from frost. In those areas where corn will produce only six tons of silage per acre, sunflowers will yield twice this quantity.

The production of forage crops in the state is determined by climate more than by all other factors combined. Most of these crops belong to the category of small seeded plants. Consequently the seedling stage is a critical period in their life history, and a crop is not established until this stage is safely passed. Rapid and complete germination, followed by a period of vigorous unimpaired growth, is essential to establishment and successful competition with other crops and weeds. As total rainfall increases, the hazard of establishment is lowered and under irrigation is almost entirely absent. On good soils in western Washington it is comparatively easy to establish grasses because of the climatic factors already discussed. Consequently western Wahington with its humid climate and irrigated Washington with water available when needed, are best adapted to the small seeded forage crops.

To evade the hazards of drouth and heat in eastern Washington the culture of large seeded forage crops, especially of the legume family, has been adopted and pea culture is prevalent. They cannot be produced economically, however, where rainfall is too limited, or where day temperatures are too high, and consequently are not used to any great extent in the more arid portions of the state or in the irrigated sections.

The commercial tree fruit crop of Washington is centered in the irrigated regions of the central and eastern part of the state primarily because of climate and the availability of water for irrigation. Since the humidity is high and rains are abundant in western Washington during the spring and fall, tree fruits in that area are particularly susceptible to injury from plant diseases, and color formation, so desirable in many commercial fruit crops, does not take place in sufficient degree. Moreover, the comparatively low, even summer temperatures of western Washington are not favorable to the production of such a crop as peaches. Prunes and nuts, however, thrive over considerable areas in such temperature and moisture conditions, hence the development of these industries in Clarke county. Bush fruits, such as raspberries and blackberries, here make the highest average annual yields in the United States.

In the low irrigated valleys of central and eastern Washington most conditions are ideal for tree fruit production, particularly apples, pears, and cherries, and peaches and apricots where there is comparative freedom from late spring frosts. Over one-fourth of the commercial apple crop of the United States is produced in Washington and the state is second in pear production. The apple crop varies less in quantity from year to year than in any other state and a higher percentage of the crop grades perfect in form and color, and in freedom from insect, disease or weather blemish than that of any other state. The orchards are exposed to a near desert climate, bright sunshine, and low humidity but with irrigation the

trees have plenty of moisture in the root zone. Usually the weather is very favorable when the trees are in blossom and fall frosts are sufficiently late to permit of a good harvest. The best districts also are free from excessively rapid low temperautre drops during the winter, which when prevalent may injure the cambium, buds and terminal growth. Occasionally the temperatures fall sufficiently low to injure the more tender species such as apricots, peaches, and cherries, and frosts at blossom time may destroy the season's crop altogether. These conditions constitute the principal hazards to soft fruit production. Fungous diseases of tree fruits grown in these areas are limited because of the dry climate. On the other hand, insects find the climate extremely desirable. Consequently the fruit grower must carry on a constant, expensive warfare for insect control, which is justified and can be continued only where other factors are favorable to high yields of good quality. The non-irrigated sections of eastern Washington with much lower yields but with equivalent insect control problems can not compete in commercial fruit with the high yields in areas irrigated from the rains and snows of the mountains.

Vegetables of one kind or another can be grown in all parts of Washington. Many vegetables, however, are specific in their temperature requirements. Some are hardy, some semi-hardy, others tender, and some very tender in respect to temperature. Lima beans and sweet potatoes, for instance, which are susceptible to frost can be grown only in restricted areas where the frost hazard in the spring is not large. Tomatoes, watermelons, muskmelons, and sweet corn do best in sections having early spring,warm summer, and long, warm falls free from frosts. These conditions are found in the lower irrigated valleys. Peas, string beans, and head lettuce thrive best in the cool, more equable temperatures of western Washington. All of the peas and most of the string beans that are canned in Washington, therefore, are produced in that section. The center of the head lettuce industry for similar reasons is located in the Puget Sound country. Irish potatoes, because of their adaptation to cool climates and to production early in the season under irrigation, are grown abundantly in Washington. Root crops are especially well adapted to the cooler part of eastern Washington and to large areas of western Washington.

Ornamental plants are produced primarily in the coastal areas. The moderate winter, abundant precipitation, and relatively dry summer, are admirably suited to commercial bulb growing. Here also the climatic conditions are favorable to a large variety of coniferous and broad leaved evergreens and shrubs.

The animal husbandry industries of Washington are less affected by climate than are crops. They are dependent primarily upon the availability of pasture, other forage and feed. Luxuriant pastures and the long grazing season of western Washington are particularly desirable for the dairy industry. The irrigated areas with long pasture seasons and an abundance of alfalfa production, likewise lend themselves to dairying. Dairy cattle also are found to some extent in the more humid sections of eastern Washington where pasture and other forage crops can be grown.

Poultry may be raised under a great variety of climatic conditions and is produced everywhere in the state. The most densely populated poultry centers are in western Washington because of the equable climate, the relatively small acreage needed for a poultry farm, the

inexpensiveness of poultry housing, the proximity to the terminals where poultry feeds may be secured from the mills and delivered at reasonable costs and where markets are accessible through co-operative organizations. With improvements in refrigeration methods of marketing which largely overcome the hazards to poultry products occasioned by the higher temperatures of summer, and with improved housing which overcomes the difficulties of poultry management under greater extremes of temperature, the other parts of the state are increasing the production of poultry and poultry products.

Sheep are produced in largest numbers in central Washington where the rainfall is limited, where early spring range is available, where summer pasture at higher elevations in the mountains are within reach, where irrigation provides ample forage for winter feed, and where the winter climate because of abundant sunshine and absence of cold weather is particularly favorable for sheep camps and lambing. On the other hand, sheep also are adapted to the general farming areas both of eastern and western Washington and are increasing in numbers on the general farm.

Beef cattle, like sheep, thrive in many climes, but follow more or less closely the range and feed producing areas. Central and eastern Washington therefore, are well adapted to them.

Hogs may be grown in many climates, but the availability of alfalfa or other pastures, and grain feed—either corn, barley, or wheat—together with market facilities, determine in large measure the areas for hog production.

Only a few of the many commercial crops grown in this country have been mentioned. There are others of large economic importance which do not thrive in our climate. Bermuda grass and Lespedeza, so prevalent in the south, are not adapted to a climate with as low temperatures as ours. Kafir, Milo, and other sorghums, important forage crops in the central and southern plains section, find our climate too cool except in the irrigated valleys of low altitude. Rice, cotton, and citrus fruits require warmth and freedom from frosts and are entirely absent.

In addition to its effect on crops and stock, climate has a large influence on our agriculture from the standpoint of management. In the Palouse and eastern Walla Walla country, for instance, the time for soil preparation and seeding in the spring usually is short, because abundant moisture in the soil often delays field operations. It would be desirable if all spring work could be done within two weeks when the ground is in the best condition and as early in the season as possible. Consequently, the farm equipment must be of a character which permits the use of time and power to a maximum, and the large type machinery, large teams, and tractors which in the main are the result of large scale farming in part are due to this factor. Similarly in the orchard sections spraying must be done at the critical periods in the life histories of the insect pests. These periods last only a few days at a time. Equipment and man-power must be sufficient to take care of the spraying load with great dispatch. In western Washington delay of a day in picking a berry crop when mature may result in large losses should rain come, thus necessitating larger picking crews and more or less intermittent work.

Again, in large parts of the Palouse and Walla Walla country in eastern Washington the snow and slush of winter necessitate better buildings and lots for hogs and other livestock than are

necessary where winter precipitation is less and the soil more sandy. In western Washington because of the moderate climate, shelter to protect from the rainfall must be provided, but warm buildings are unnecessary. More or less open houses for poultry and loiter sheds for livestock, therefore, are common in this section.

These examples of the influence of climate on agriculture might be multiplied manyfold. However, from the standpoint of the influence of climate both on crop growth and on livestock production and the effect that it has on the farm layout and farm management, one cannot fail to arrive at the conclusion that the climate is one of the major determining factors on the type of agriculture in any region and that crop and livestock production and farm management in the long run in large measure adjust themselves to the climatic conditions of the area.

The Eighth Annual Meeting

By
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THE members of the Northwest Scientific Association assembled for their eighth annual meeting at Spokane, Washington, on December 29th and 30th, 1931. Notwithstanding the anticipation that the attendance might be reduced, over 170 members of the association were present, in addition to numerous guests. This constitutes the largest attendance yet recorded at any annual meeting, being an increase of approximately eighteen per cent over that of the largest previous meeting.

The meetings were presided over by President Ernest O. Holland of the State College of Washington, president of the organization for the year 1931. At the opening meeting, on December 29th, President Homer L. Shantz of the University of Arizona, was to deliver an address on the subject, "The Vegetation of the United States and its Relation to Agriculture." Unfortunately, President Shantz was unable to leave Arizona because of a special session of the legislature. In his absence his place was filled by Dr. E. F. Gaines, of the State College of Washington. Dr. Gaines related impressions of Russian scientists and the Russian experiment stations, gathered during a year of study and travel in Europe in 1930-31. On the same day a broadcast through the courtesy of the National given under the auspices of the Asso- Broadcasting System was to have been ciation, the speaker being Dr. George D. Louderbeck of the department of geology of the University of California. Due, however, to a severe storm, wire conections were suspended and the broadcast was cancelled.

In addition to the general sessions, sectional meetings were held by the following sections: Botany-Zoology, Chemistry-Physics, Education-Psychology, Engineering, Forestry, Geology-Geography, Medicine-Surgery, and Social Science. On the morning of December 30th a joint session of several of the sections was held, the symposium topic being, "Climate and Its Relation to Science in the Northwest".

At the general meeting on December 30th the Association passed resolutions commemorating the service to

science of Dr. W. J. Spillman, a former member of the faculty of the State College of Washington, later a nationally known figure in the field of agricultural economics and of Dr. B. L. Steele, a member of the Association and of the faculty of the State College of Washington at the time of his death.

A resolution was also passed requesting that the members of the Agricultural committees from the Northwest in the House and Senate direct their attention to the menace to agriculture arising from soil erosion.

At a council meeting of the association the officers and councilors decided to make the coming meeting of the Pacific Division of the American Association for the Advancement of Science to be held at Pullman, Washington, on June 15-18, 1932, a special meeting of the Northwest Scientific Association and to cooperate in every way possible to make the meeting successful. To this end President Holland appointed a contact committee from the Association consisting of the following members: C. C. Todd, chairman; J. W. Hungate, H. B. Barss, John W. Finch, L. K. Armstrong, Charles H. Clapp, F. A. Thomson, Alfred Atkinson, I. N. Madsen, and R. E. McConnell. The secretary reported that the Association is now connected with the A. A. A. S., having affiliated as an academy in April, 1931.

The following officers will serve for 1932:

President: Ivan C. Crawford, Dean of the College of Engineering of the University of Idaho, Moscow, Idaho.

Vice-President: T. C. Spaulding, Dean of the School of Forestry of the State University, Missoula, Montana.

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Trustees: President F. A. Thomson, School of Mines, Butte, Montana; Thomas Large, Lewis and Clark High School, Spokane, Washington, and L. K. Armstrong, 704 Peyton Building, Spokane, Washington.

E. E. Hubert, editor of Northwest Science, the official publication of the association, was reappointed for the year 1932. The assistant editor will be A. L. Anderson of the Department of Geology, University of Idaho, Moscow, Idaho.

The following were elected as chairmen of the various sections: Botany-Zoology: H. B. Stough, University of Idaho, Moscow, Idaho; Chemistry-Physics: G. L. Luke, University of Idaho, Moscow, Idaho; Education: C. I. Erickson, State College, Pullman, Washington; Engineering: H. H. Langdon, State College, Pullman, Washington; Forestry: S. N. Wyckoff, U. S. Blister Rust Control, Spokane, Washington; Geology-Geography: John W. Finch, University of Idaho, Moscow, Idaho; Medicine-Surgery: Dr. D. Hartin, Old National Bank Building, Spokane, Washington; Social Science: T. S. Kerr, University of Idaho, Moscow, Idaho.

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Vol. VI Number 2

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N87

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NORTHWEST SCIENCE

Entered as second class matter April 5, 1927, at the Post-Office at Cheney, Washington. Office of Publication, Cheney, Wash.

Published quarterly at a subscription price of $1.00 per year, which includes the membership dues of the Association. Non members $1.00 per year. Vols. I (1927), II (1928), III (1929), IV (1930), V (1931), complete, each $1.25.

Reprints of articles appearing in regular issues will be furnished to the author at the following rates, *provided they are ordered prior to the time of going to press.*

Pages	2	4	8	12
100 copies without cover	$2.50	3.00	5.45	5.95
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300 copies without cover	3.75	4.50	7.00	10.00
300 copies with cover		6.25	8.75	11.75

Printing of plates extra, at actual cost

NORTHWEST SCIENCE

VOL. VI JUNE, 1932 No. 2

The Association is not responsible, as a body, for the facts and opinions advanced in the papers published by it.

EDITORIAL

This number of Northwest Science is devoted wholly to the publication of geological papers and is in accordance with the plans of this year to make the June number a geology number. It marks the first time that any number of the journal has been given over entirely to one branch of the sciences. There has long been a demand that papers of like kind, and especially the geological papers, should be assembled and published together. Such procedure should naturally increase the effectiveness of the journal and should attract greater outside interest. It is hoped therefore that the geology number may be continued in future years, and that sufficient demand be aroused among other branches of the sciences to establish other special numbers similar to the one started in this issue.

Geology has a greater popular appeal than most other sciences. There are few people, indeed, who are not curious about the earth and the natural features seen upon it. But only a few, the trained geologists, are able to interpret the earth's features and to explain their origin. To them the rocks, the hills, the valleys, the streams, the mineral deposits, etc., tell most fascinating stories. It is the duty of the geologist to relate these stories to the rest of mankind. Unfortunately, these accounts often become so involved through the use of technical terms that they are not always understood by the untrained reader. It is hoped that the geologist will give greater consideration to the general reader and garb his story in more simple terms. By so doing he can increase popular interest in the earth's features and their origin, and give his science even greater appeal.

Few regions in the world has so diverse and so interesting geological problems as the Northwest. In the region comprising Washington, Oregon, Idaho, and Montana, with its great mountainous area, its vast lava plains and plateaus, its profound canyons, its lakes, its minerals, there exists a veritable geologist's paradise. Much of its geology is as yet unstudied and from its vast size cannot be covered for many years. From such work as has been done, however, there have come problems of tremendous interest. One need only to cite the great channeled scabland tract of central Washington where almost inconceivable floods of glacial waters carved mighty canyons and formed waterfalls of such size as to dwarf the largest fall of the present day. It is only necessary to mention the Grand Coulee. Nowhere on earth are there features compar-

able with the scabland and cataract country of the Columbia Plateau. Nowhere on earth has a stranger story been reeordcd.

Other organic features have attracted country-wide attention. The development of the Idaho mountains has been a subject of wide controversy and is as much unsettled now as when the discussion first started nearly two decades ago. There are problems in glaciation yet to be solved, also problems in stream drainage. In fact, study of physiography of the Northweast has barely begun. It will require many years to work out the details. Such is also true of the structural history of the region. In Montana and Idaho are some of the most interesting mountain structures in the world—great folding and overthrusting—also vast batholithic intrusions. The region is a paradise for the structural geologist, the petrologist, and the petrographer, as well as for the physiographer. The field has scarcely been touched by the stratigrapher and paleontologist, nor is the economic geologist more than well started. Many problems are of local interest only, but many are also of country-wide and world-wide interest. The Northwest geologist is indeed fortunate in having such a fascinating field for his researches.

The Clays of Tertiary Age in Northern Idaho and Eastern Washington[1]

By

EDWARD L. TULLIS and F. B. LANEY

University of Idaho, Moscow, Idaho

THIS paper discusses the distribution, extent, present and possible utilization and reserves of the white clays of this region. The classification and geological occurrence, as well as the mineralogical composition and origin, of the clays are discussed.

The deposits are located in Latah, Benewah and Kootenai counties, Idaho, and in Spokane, Stevens and Whitman counties, Washington. Deposits are numerous and in many cases of wide extent with reserves probably as great as in part of the U. S. At present the clays are confined to the making of fire brick, face brick, and structural wares, and are sold raw as prepared fire clay. Research work has shown that some of the material can be refined and made into a good grade of china clay. The clays are considered as two types, residual and transported, and occur along the margin of the Columbia basalt against the older rocks. The first type consists of a group of the "kaolin minerals," largely kaolinite, together with quartz, micas and accessory minerals of the original rock. The transported clays consist of essentially the same minerals with the kaolin minerals present in a greater concentration than in the residual clay. These were deposited in lakes and ponds formed in middle Tertiary time by the outpouring of the basalt. Two possible modes of origin, hydrothermal and weathering, are discussed, and it is concluded that the evidence obtained favors the latter.

---

[1]Abstract of paper presented at the Annual Meeting of the Northwest Scientific Association, December 29-30, 1931, Spokane, Washington.

A Major Overthrust in Western Idaho and Northeastern Oregon[1]

By
D. C. LIVINGSTON
University of Idaho, Moscow, Idaho

OVERTHRUST faulting has been shown to be a major structural feature in northwestern Montana, extending across the Canadian border, at Philipsburg, Montana, in southeastern Idaho and Western Wyoming, along the Bitteroot Mountains between Idaho and Montana, and in northern Utah. A summary of these faults, showing the general characteristics and the direction of the thrusts, with a complete list of references as to the sources of information, has been given by G. R. Mansfield.[2] Accompanying this summary is a sketch map showing the location of the principal overthrusts that have been reported and mapped by different observers.

This map does not extend any farther west than approximately the 113th meridian and therefore does not include central and western Idaho and northeastern Oregon. The natural inference from this is that no overthrust faults of any magnitude have been reported from these regions. In so comprehensive a review as that written by Mr. Mansfield any reference to this type of structure in the Rocky Mountain region of the northwest states would undoubtedly have been mentioned, and the above inference can be taken as substantially correct.

This particular region, which includes central and western Idaho and a part of northeastern Oregon, is decidedly rugged and difficult of access in many parts, and most of the geological work that has been carried out has been of purely reconnaissance and of an economic nature. Large areas are underlain by granitic and marginal metamorphic rocks in which faulting is hard to trace even under the best of circumstances, and, under reconnaissance conditions, discoveries of overthrust faults in this region would be almost miraculous.

That this region should have been exempt from the same stresses as those which produced the overthrusts immediately to the east of it seems contrary to the laws of probability, as these thrusts have all been from the west. Such a condition seems unlikely, and this paper is written to describe a structural feature in western Idaho and northeastern Oregon which is more easily explained as a major overthrust than by any other hypothesis. This thrust fault extends along the Idaho-Oregon border, which is also approximately the western border of the eroded mountain mass of central Idaho.

The writer spent portions of eight field seasons in the region traversed by this fault, and, of this time, nearly two months were spent in working out the complex geology of about three square miles at the old silver camp of Mineral, Idaho, through which this thrust fault passes.

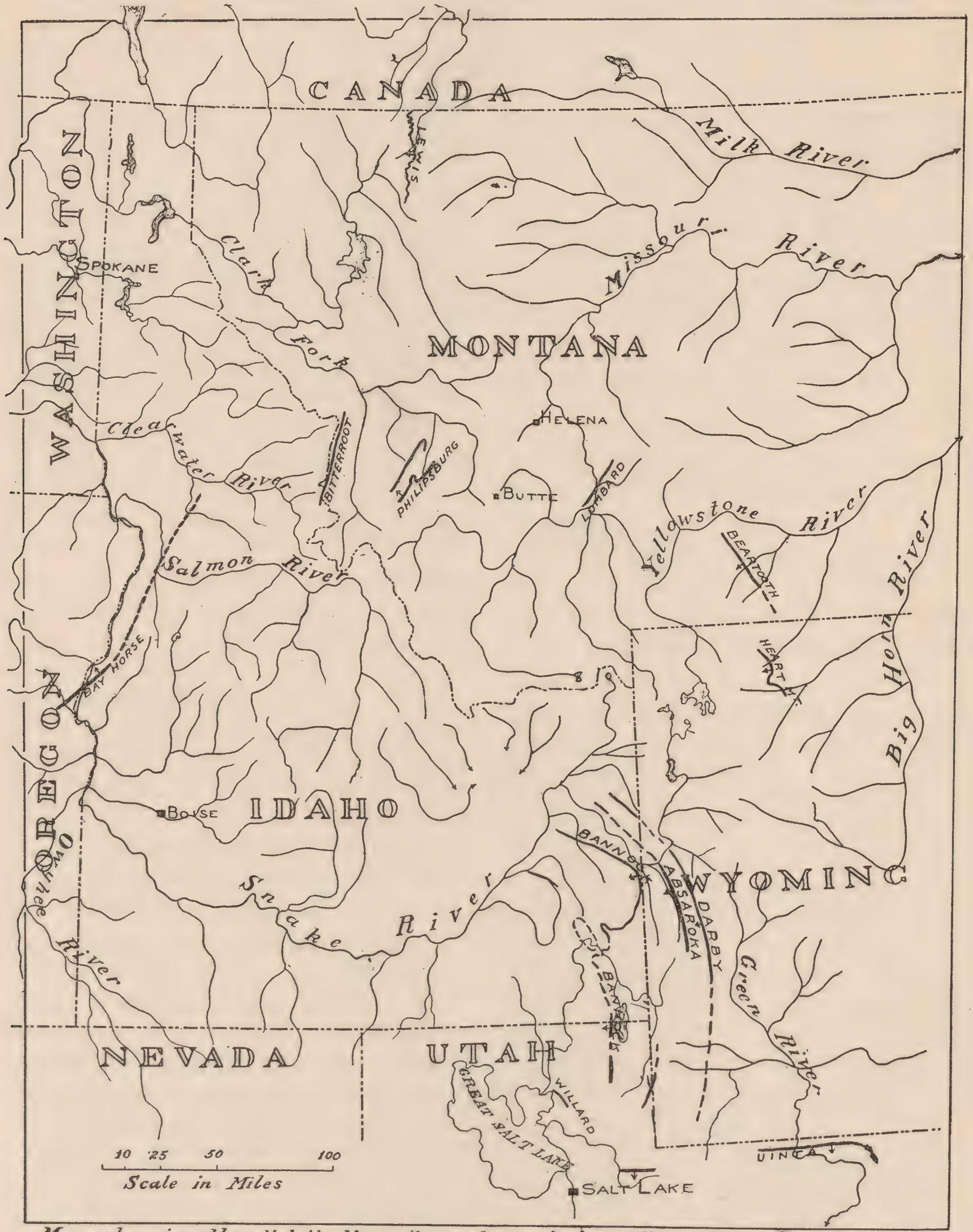
This fault might be termed the Snake River overthrust, except for the fact that this name has already been used in southeastern Idaho. Accord-

[1]Presented at the Annual Meeting of the Northwest Scientific Association, December 29-30, 1931, Spokane, Washington.

[2]Mansfield, Geography, Geology, and Mineral Resources of part of southeastern Idaho; U. S. Geol. Survey Professional Paper No. 152, p. 379.

ingly, the name Bayhorse overthrust has been tentatively assigned, as this fault crosses Snake River just below

dy Mountain, Idaho, a distance of between forty and fifty miles. It can be followed from the lime quarry at



Map showing the distribution of overthrust faults in the northern Rocky Mountains. Adopted from Geo. R. Mansfield and extended westward.

the old Bayhorse mine. It can be traced from Burnt River, Oregon, to Cud-

Lime, on Burnt River, about six miles above Huntington, through the gyp-

sum quarries on top of the ridge between Burnt River and Snake River, past the old Bayhorse mine and thence across Snake River and through the old camp of Mineral, Idaho, on Dennett Creek. It disappears below the basaltic cap of Hitt Mountain, but reappears again on the south side of Cuddy Mountain, being again hidden on the north side of that mountain by basaltic flows of the Columbia Basin. It has not been traced through the Seven Devils Range, but a schist zone underlying limestone near Slate Creek in the canyon of Salmon River is worth investigating on the possibility that this fault extends across that river toward northern Idaho.

In most of the places where exposed, the fault has very nearly the same strike and dip as the underlying formations. Accordingly, it appears at first glance to be a part of a series of conformable beds composed of different kinds of rock strata. The strike of these strata is N40°E. to N50°E., of the dip varies from 20° to 60° northwest. The direction is remarkably uniform so far as traced. The above, therefore, is approximately the strike and dip of the fault.

This fault crosses part of the region covered by Lindgren[1] in 1900, and is mapped by him as a contact between Triassic lavas, and limestones and shales of presumably the same age. This indicates that the contact is a prominent structural feature inasmuch as it is recorded on a reconnaissance map. On the same map Lindgren shows Paleozoic rocks outcropping to the west which would place them stratigraphically above the Jura-Trias on the east. As the whole series dips to the west, as shown on Lindgren's map and checked in a number of places by the writer, it is difficult to account for this sequence except by an overthrust. The writer believes that the argillites overlying the Jurassic beds at Mineral belong to the same series as those exposed above Sumpter, Oregon, and along Burnt River, and there recorded by Lindgren[2] as probably early Paleozoic. Accordingly, if the Paleozoics were extended eastward to the line of this contact, Lindgren's map and the findings of the writer would be in perfect accord. Lindgren indicates at Mineral, Idaho, the possible presence of Paleozoic rocks by means of that symbol accompanied by a question mark. The position of this questioned symbol on his map would place Paleozoic rocks immediately above Jura-Trias, which is confirmed by the writtr.*

The sequence of formations exposed in the canyon of Dennett Creek, where the old comp of Mineral is located, is as follows:

The lowest rock exposed is a quartz diorite sill. The bottom of the sill has not been exposed but the top grades through a purplish andesitic phase into a reddish rock to which the field name of Lower Rhyolite has been assigned to distinguish it from a flow of rhyolite higher in the series.

Immediately above this reddish rock lies a fine gray sandy tuff, which merges upward into a series of coarse pebble conglomerates. Above the conglomerate lie more tuffs, darker in color, and above these a series of dark carbonaceous and calcareous shales about 200 to 300 feet thick. The

[1]Lindgren, Waldemar, Gold Belt of the Blue Mountains of Oregon: 22nd Annual Report of the U. S. Geological Survey, Part 2, p. 562.

[2]Op. Cit. p. 577

*In a personal communication Dr. Lindgren wrote as follows: "I will say offhand that I believe you are well justified in placing an overthrust fault with northeasterly strike in the vicinity of Mineral, Idaho. The only reason I did not place it there at the time, thirty years ago, was the apparent conformity of the beds and at that time anyway there was little information on the overthrusts of the western country."

whole series from the top of the quartz diorite to the top of the shales is between 500 and 600 feet thick.

The shales yield excellent fossil ammonites which have been identified by Dr. Packard of the University of Oregon, and by Dr. Ralph L. Lupher of Washington State College, as Upper Jurassic in age.

Above the dark carbonaceous shales is a rhyolitic rock, probably a flow. It varies in thickness from 50 to 200 feet. In many places it has been eroded from the shales.

Above the rhyolite is a peculiar greenish to purplish and reddish schist from 200 to 250 feet thick. This schistose rock is overlain by limestone and contains, near the limestone contact, lenses of gypsum. These appear to have been formed by the action of sulphated waters on the limestone, forming first anhydrite which was later hydrated to gypsum by atmospheric waters. An interesting topographic accompaniment of the gypsum is landsliding. The larger the gypsum beds, the greater the landslides. The largest of the landslides is at Gypsum, Oregon, where the top of the ridge has slid down to form a flat about three hundred feet above the level of Snake River, a total vertical movement of 1500 feet. Oversteeppening of the mountain, due to the formation of the gypsum plus the activities of two small confluent gulches, was the cause of this slide. At Mineral, Idaho, landslides due to gypsum formation are insignificant as the gypsum beds are quite small. At Gypsum, on the mountain above the Bayhorse Mine, and across the river from it, landslides, due to this cause, are prominent topographic features.

This so-called schist is a slickensided agglomerate containing in some places fairly coarse pebbles. In other places pebbles are missing and the fine schistose matrix comprises the larger part of the rock. The pebbles are usually, but not always, flattened, and there are occasionally places where both the schistose structure and the flattened pebbles are absent and the rock grades into an apparent agglomerate. The characteristic structure and striking green, red and purplish colors of this rock are easily recognisable. It is the most significant formation of the series from a structural point of view. The name schist is a misnomer as the rock is probably an indurated fault gouge for which no name has been devised so far as the writer is aware.

A description of a big fault zone in the Bitterroot Range by Lindgren[1] can be applied very well to the zone of the Bayhorse thrust. The following is from Lindgren. "The fault zone is composed of gneiss which is clearly nothing but a sheet of pressed deformed granite. It is usually a light gray granular and schistose rock and consists of lenticular squeezed aggregates of oligoclase and quartz and deformed orthoclase crystals, separated by somewhat curved aggregates of new-formed biotite and muscovite. The primary constituents are the same as those of the granite. All transitions toward granite may be seen. Excessive compression results in finer-grained and darker micaceous schists. This gneiss is characterized by *abundant slipping planes, which show movement parallel to the dip** and on which large plates of muscovite have been formed." Substitute a vari-colored volcanic tuff for granite and we have an exact dup-

[1]Lindgren, Waldemar, A Geological Reconnaissance Across the Bitterroot Range and Clearwater Mountains in Montana and Idaho, U. S. Geological Survey, Professional Paper No. 27, p. 20.

*Italics are the Author's.

licate of this fault zone at Bayhorse, Mineral, Gypsum, etc.

Above the fault gouge at Mineral is a crystalline limestone bed from 50 to 100 feet thick and above the limestone is a great thickness of gray argillites or clay slates, locally containing lenses of limestone. The argillites represent the metamorphosed equivalent of a fine-grained mud rock and are entirely different from the finely laminated, dark, carbonaceous Jurassic shales that underlie them. The argillites indicate dynamic metamorphism while the black shales, with their perfect fossils, do not.

It was this incongruity at Mineral that hinted at the possibility of an overthrust fault, a structure which is not indicated by the conformable relationship of the beds but which is suggested by the occurrence of unaltered fossiliferous shales overlain by highly altered mud rocks, now in the form of argillites or slates. At other points along the strike of this suspected fault, confirmatory evidence has been found which throws considerably more light upon this structure. A rough porosity test of the argillites and the underlying calcareous Jurassic shales shows the underlying rocks to be decidedly more porous than the overlying argillites.

This fault has been only partly traced, between Mineral, Idaho, and the Bayhorse mine, Oregon, owing to the fact that it is largely obscured by flows of Columbia River basalt. At the Bayhorse mine, however, an excellent section can be obtained. Here, movement, as indicated by slickensided fault breccia, has occurred through a much wider zone than at Mineral and has not been confined to one plane. At the Bayhorse there are two distinct fault zones, about three hundred and two hundred feet thick respectively, separated by nearly one thousand feet of limy shales, gypsum formation and massive limestone blocks. The black carbonaceous shales are missing. The upper fault breccia, which is two hundred feet thick, lies above the limestone and below the argillites. The whole 1500 feet indicates a zone through which movement has taken place, but most of the movement has been confined to the two fault zones, represented by the purplish breccia and schist at the top and bottom of the main zone.

Similar conditions prevail at Gypsum. There the schistose gypsum formation, which is overlain by limestone lenses, and still higher by a thick fault breccia (thickness undetermined but several hundred feet at least), rests unconformably upon a series of tuffs and agglomerates which are believed to be Permian[1] in age but which may be Triassic. The relationship between these rocks and the Jurassic series described at Mineral is at present rather obscure. Transitional formations apparently occur along the Snake River Canyon about half a mile above the Bayhorse mine.

On Cuddy Mountain, some twenty miles to the northeast of Mineral, the same fault[2] is exposed near the head of Grade Creek, a tributary of Brownlee Creek. It there shows the same slickensided breccia lying between conglomerate and rhyolite flows below and argillites above. A small amount of gypsum occurs here also. The intervening country is largely covered by basaltic flows. This fault was wrongly interpreted by the writer when mapped for his report in 1922.

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[1]Kirkham, Virgil R. D., Igneous Geology of southwestern Idaho, Journal of Geology, Vol. XXX, pp. 564 and following.

[2]Livingston, D. C., A Geological Reconnaissance of the Mineral and Cuddy Mountain Mining District, Washington and Adams Counties, Idaho, Idaho Bureau of Mines Pamphlet 13, p. 22.

Some fifty miles northeast of Cuddy Mountain a similar schist zone crosses Salmon River near Lucile. Limestone lies above the schist zone at the mouth of Cow Creek, opposite to Lucile. The appearance of these formations is suggestive of the same kind of overthrust, but this district has not been studied in detail.

Again thirty miles to the northeast, Anderson[3] has mapped a series of Triassic(?) greenstones and limestones, etc., on the South Fork of the Clearwater River near Harpster, Idaho, in contact along a northeast course with schists and gneisses of igneo-sedimentary origin. According to verbal information from Mr. C. D. Emigh, who assisted a United States Geological Survey party, in cooperation with the Idaho Bureau of Mines and Geology in mapping the Newsome quadrangle, this same contact, a little farther north, might very well be a fault-gneiss contact like the zone described by Lindgren for the Bitterroot fault to the east.

Whether this is so or not, along the Salmon River near Lucile and Slate creek and west of Riggins and along the South Fork of the Clearwater and the adjacent mountains, the possibility of the existence of this overthrust should be considered. Evidence we now have suggests the possibility of its continuation to the northeast. If found to continue from Burnt River Oregon, to the Clearwater Mountains, Idaho, this thrust would have a length of 125 to 130 miles.

From study of this fault along Snake River, the inference is plain that it is a thrust of considerable magnitude, in spite of lack of fossil evidence in the overlying limestones and argillites. The probabilities are that these rocks will be found to be early Paleozoic in age, the same as the formations at Burnt River described by Lindgren.[1] The argillites and limestones at Connor Creek, Oregon, contain the same type of mesothermal gold bearing quartz deposits as those from Cracker Creek, which are believed to be of this age. The general strike of the thrust is northeast with a variable but somewhat flat dip. The thrust came apparently from a northwesterly direction. At least the overlying block has moved northeastward.

An invariable accompaniment of this thrust is a series of apparent complementary normal faults.[2] These faults usually strike a little north of west and have a somewhat flat dip (not usually over 30 to 35 degrees) to the southwest. They are prominent at Mineral where they have cut the formations into a series of parallel blocks about a quarter of a mile across. They also show very plainly at the Bayhorse mine. In fact the silver-bearing tetrahedrite ore body which occurs there lies against one of these southward-dipping and flattish normal faults. Another of these complementary faults has displaced the formation nearly half a mile horizontally, up Snake River immediately above the Bayhorse mine.

As this overthrust fault is apparently older than the Miocene basalts and cuts Jurassic beds, it must be post-Jurassic and pre-Miocene in age.

Its total movement has not been estimated and might be very difficult to determine.

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[1]Lindgren, Waldemar, Blue Mountain Reconnaissance, op. cit. p. 577

[2]Leith, C. K., Structural Geology, p. 78

[3]Anderson, Alfred L., The Geology and Mineral Resouces of the Region about Orofino, Idaho, Idaho Bureau of Mines and Geology, Pamphlet No. 34. See map.

Origin and Economic Value of The Scabland Mounds of Eastern Washington[1]

OTIS W. FREEMAN
State Normal School, Cheney, Washington

THE numerous, small, scattered mounds of fine volcanic dust in the scablands of eastern Washington have an important bearing upon the agricultural economy of the inhabitants. Bretz has described the channeled scablands and has presented a theory for their origin.[2] A theory accounting for the origin of scabland mounds has been given by the writer,[3] who, in the present paper, discusses the relationships between the mounds and the activities of man.

Features of Scabland Mounds

The scablands of eastern Washington cover 2,800 square miles, and there are tens of thousands of scabland mounds. They occupy every sort of situation on the basaltic scab rock, even the top of small buttes little larger than the mounds, but they usually avoid other kinds of rock or soil. The mounds are unlike dunes, being stationary in position and of generally oval shape elongated down the slope of the land without regard to wind direction. The mounds vary in diameter from a few feet to over one hundred feet, with an elevation above the scab rock from a few inches to about four feet. With few exceptions mounds occur above depressions in the basalt. The constituent material is volcanic ash, differing markedly from the basalt bed rock and the soil of the Palouse hills adjacent to the scablands.

The flood that created the scablands not only scoured off the surface soil and weathered rock, but also left the surface of the basalt bed rock pitted by potholes and other depressions resulting from the selective plucking action of swift-running water on fractured basalt. The depressions usually contained some clay, sand, gravel, and chips of weathered basalt left after the flood waters disappeared. After the flood good-sized potholes became ponds, and large basins became lakes. Accumulations of sediment in minor depressions probably provided the first available sites for grass and other plants.

Waters and Clement[4] have presented evidence favoring the origin of the mounds by erosion of volcanic ash through the agency of running water in which furrows cut to bedrock. The main furrows have separated the ash beds into strips, and finally "tributaries" have caused the segmentation of the strips into mounds which elongated with the slope. The theory of the writer accounts for the mounds from the retention of wind deposited material by vegetation which started first and grew best in depressions worn in basalt by the Spokane flood. The writer has now modified his views and agrees in principle with the erosion theory, but the occurrence of mounds above depressions in the scabrock can-

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[1]Presented at the Annual Meeting of the Northwest Scientific Association, December 29-30, 1931, Spokane, Washington.

[2]J. Harlen Bretz: *The Channeled Scablands of Eastern Washington.* Geogr. Rev., Vol. 18, 1928, pp. 446-477, contains bibliography of other articles on the scablands.

[3]See O. W. Freeman in *Science,* Vol. 64 (N. S.), 1926, pp. 450-451.

[4]Aaron Clement Waters and Chas. W. Flagler, "Origin of Small Mounds on the Columbia River Plateau". Amer. Jour. Sci., Vol. 18, pp. 209-224, Sept. 1929.

not be the result of accident and requires explanation. The probable course of events was the following. Sometime after the Spokane flood volcanic ash fell in eastern Washington. Grass and other plants already growing in depressions in the scablands quickly pushed through the ash and protected it from erosion. Winds probably shifted some of the light material into the depressions where the

Figures 1 *and* 2.—Photograph and sectional drawing of a scabland mound in a cutting on the railroad between South Cheney and Amber with drawing of same, illustrating the manner in which the mounds occur above depressions in the scabrock. Gravel and a few water worn boulders of basalt occuur in the lower part of the mound. As usual grass grows luxuriantly on the mound.

vegetation would retain it. Between the depressions the absence or scanty character of the vegetation allowed rapid erosion and there the ash soon disappeared, leaving the residue of the ash in mounds above the depressions.

Economic Aspects of the Mounds

Areas of tillable soil are in demand in the scablands since most of the surface consists of scab rock. The scab rock provides scanty grazing and above the 15-inch isohyet supports yellow pine forest, but it is impossible for crops. Gravel or sand and other water-laid deposits allow excessive drainage, and agriculture on them in the semi-arid climate of eastern Washington is not very successful. Peat and muck soils of drained swamps are used for timothy, alfalfa, and grain hay. The fields of peat soil are irregular in shape but constitute the largest areas of tillable soil available in the scablands. Hence they largely determine the location of farm buildings, the number of dairy cows and other live stock kept, and the income of the farmers. However, scabland farmers rarely have enough meadowland for their needs, and from necessity they cultivate scabland mounds.

The advantages of scabland mounds for agriculture are that their soil is deep, fertile, easily worked, retentive of moisture, and free of stones. Mounds that have formed above depressions have soil several feet deep since the material extends below the level of the surrounding scab rock. Their soil has been formed so recently that the profile is immature, and little leaching of the virgin fertility has occurred even where the natural vegetation consists of trees rather than grass. The fact that mounds are lenslike,

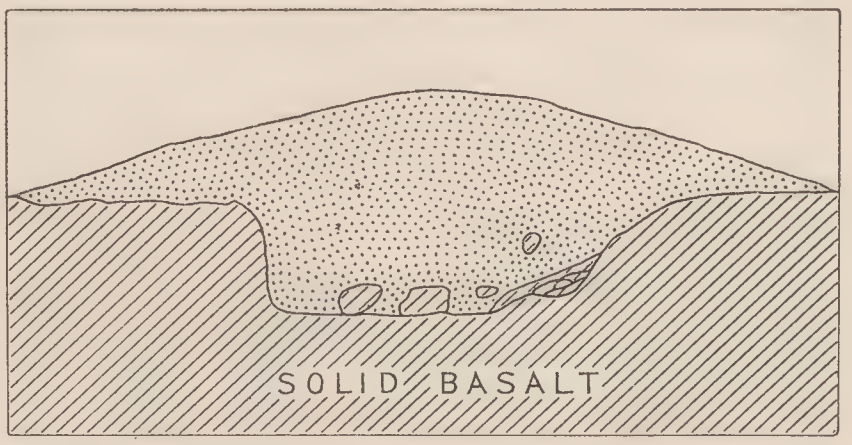

Figure 2.—Scabland mound sectioned by a railroad cut near Cheney, Wash. The depression was caused by erosion of basalt by the Spokane flood, and was later covered by falls of volcanic ash. Erosion removed the ash from the bare basalt where plants were few, but at depressions it is believed that more luxuriant vegetation prevented the removal of the ash, that remained as mounds above the depressions. Plants would stop and probably retain ash drifted in by the wind and thereby cause some growth of the mounds.

with about as much material below the general surface level as above it, provides a pocket for holding moisture. The fine material of which the mounds are built also helps to retain the water. This reservoir of moisture keeps the grass and crops of the mounds green

during the customary summer drought when vegetation around dries up completely. The soil, being a wind deposit, contains no stones near the surface.

The disadvantages of the mounds for agriculture are that their small size—from several hundred to a few thousand square feet—makes plowing and cultivation slow and awkward and that their isolated location makes utilization somewhat difficult. Only single plows can be used, and more time is spent turning the team than in useful labor. Tractors are not feasible since a large machine would nearly cover an ordinary mound. Grain hay raised on mounds is sometimes mowed with the scythe because of the difficulty of using a mowing machine. Many mounds are too isolated and inaccessible for economic use for crops.

Figure 3.—Scabland mounds near Clear Lake. These mounds are oval with the longer axis down the slope. They are nearly of equal height. The top of the largest mounds is flattish.

Almost every crop grown in eastern Washington can be found planted on scabland mounds. Wheat, rye, oats, barley, sweet clover, peas, corn, timothy, alfalfa, watermelons, and garden truck were noted in the vicinity of Cheney during the summer. Grains are rarely allowed to ripen. They are usually cut for hay, of which the scab-

Figure 4.—Corn growing on scabland mound near Badger Lake. Fenceposts on scabrock supported by braces.

land dairymen usually have need because of the small acreage of tillable land on their farms. Corn, squash, watermelons, and home gardens thrive on the mounds since the supply of moisture stored in the lower part of the mounds adequately furnishes water to the plants which do not depend on artificial irrigation or summer rain. A successful grower of melons for market near Cheney plants three or four hills to each mound. On many farms in the scablands the mounds are the only available spots for gardens, the soil being especially adapted for this. In one recent year the winner of the school garden club at Cheney raised his vegetables on scabland mounds.

In scab-rock areas used for grazing the best grass and other plants grow on the mounds. If not eaten by stock the grass may be high enough to cut for native hay. The value of scab-rock pastures and the live stock they support is proportional to the number and size of mounds present.

The mounds, being the only soil in areas of scab rock in which digging is easy, serve as homes for burrowing animals, especially ground squirrels. For the same reasons man has used mounds as sites for root cellars. Occasionally both whites and Indians buried their dead in the mounds. Shallow wells have been dug in mounds on low land, but usually the water present is all capillary water and insufficient for domestic supply. If unpaved highways cross mounds, bad mudholes develop, since water saturates the materials in the depressions and disappears slowly by evaporation and percolation. Mounds are chosen, if possible, for holes when fence posts and telephone poles are to be set in scab-rock areas, since otherwise tripods, piles of stones, and other means of bracing must be used for support.

Figure 5.—Rye, intended for hay, near Medical Lake in July, 1928.

Recent Developments in Montana Gas Fields[1]

By

EUGENE S. PERRY

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Montana has three general areas in which gas is found. These are (1) the southeastern portion of the State, (2) the south-central portion, and (3) the north-central portion.

In the southeastern portion is that long anticlinical structure known as the Baker-Glendive anticline along the crest of which about 125 gas wells have been drilled. In the south-central area are the new Dry Creek field, the Elk Basin field, the Lake Basin field and the Hardin field. In the north-central area are numerous gas producing areas chief of which are the Kevin-Sunburst-Shelby field, the new Cut Bank field, the Sweetgrass Hills area, the Bowes field, and the Bowdoin-Saco field. New wells have been drilled in all these fields but in this paper mention is made only of those outstanding in importance.

Perhaps the most spectacular development of any gas field in Montana was the bringing in of 21 successive commercial wells in the Cut Bank field about ten miles north of the town of Cut Bank. The average initial daily flow for these wells is slightly in excess of 10 million cubic feet per day each, and the "closed-in" or "rock" pressure is approximately 750 pounds per square inch. One well showed an open flow of 37 million cubic feet of gas per day. The depth to the productive horizon, which is a sandstone of Kootenai (Lower Cretaceous) age, ranges from 2600 to 2900 feet. The gas is of high quality. This group of wells was started and completed within a period of six months from May to November 1931.

In the Sweetgrass Hills area several new "finds" have been made. Although this area has long been known to be productive of gas, its importance was not generally realized until after the drilling during 1931 of several new wells, the largest of which produced 9 million cubic feet per day, with a pressure of 600 pounds, from a depth of about 2000 feet.

Another new area was made known by the drilling of a seven-million-foot gasser, eight miles southeast of Havre. Additional wells have not been drilled in this area, which is known as the Box Elder Structure.

In the heart of the old producing area of the Baker field, where wells of 2 and 3 million cubic feet per day have been obtained, deeper drilling made known another horizon, approximately equivalent to the Judith River formation, from which wells producing from 16 to 28 million cubic feet per day could be expected. The depth is 860 feet. Also new wells have extended the Baker field far to the south so that now the productive area is more than 75 miles long.

In the Dry Creek field deep drilling has revealed gas reservoirs at about 5000 feet depth. Wells produced approximately 10 million cubic feet of gas per day under 1400 pounds pressure.

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[1]Presented at the Annual Meeting of the Northwest Scientific Association, December 29-30, 1931, Spokane, Washington.

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It is interesting to the geologist that all Montana's commercial gas comes from Cretaceous formations. Gas in large volume is found in Mississippian and Devonian formations, but due to high sulphur content, or to high nitrogen or carbon dioxide content, gases from these horizons are unsuited to domestic use.

In the Kevin-Sunburst-Shelby field, and the Dry Creek field the productive horizons are sandstone members of the Lower Cretaceous which compose the Kootenai formation in northern Montana and the Dakota formation in southern Montana. In the Baker-Glendive field, the Bowes field, the Lake Basin field and in parts of the Sweetgrass Hills area, the productive horizons are in approximately the middle of the Upper Cretaceous, in sandstone members locally known as Eagle and Judith River. In the Bowdoin-Saco and Hardin fields the productive horizons are sandstone members of the Colorado shale which in turn is the lower portion of the Upper Cretaceous. The Frontier sand, a member of the Colorado formation, also produces gas in the Lake Basin and Dry Creek fields.

Depth to producing horizons depends entirely on local structural conditions, and ranges from 500 feet to 5,000 feet, with most wells lying within a depth-range of 1,000 to 3,000 feet.

One of the significant features of Montana gas wells is the amount of "closed-in" or "rock" pressure. Pressure shows an increase with depth at the rate of approximately 1 pound for each 3.5 feet. Evidently very definite physical conditions are controlling gas pressures. Certain causes for pressure commonly given by investigators are (1) hydrostatic pressure, (2) compression of beds due to weight of superincumbent strata, and (3) natural generation of gas from solid organic matter in the source rocks. Perhaps still other factors affect gas pressures.

The origin of Montana gas, as elsewhere, no doubt, is in organic material buried in the sediments at the time of their deposition. Most geologists are inclined to think that the source rocks are marine shales, and that the organic matter is finely divided and disseminated through the shale. As the solid organic matter decomposes, the gas, (or oil) migrates from the fine grained source rock into the coarse grained reservoir rock. After arriving in a reservoir, migration continues until some structural trap prevents further movement. Montana gas occurrences fall nicely into this general theory. Much organic shale is found in all gas producing areas.

The types of structural traps in Montana are essentially (1) anticlines and domes (2) areas of greatly increased porosity within shaly sandstones and (3) sandstone lenses.

In general the prospecting for natural gas in Montana during 1931, has been featured by many large wells in new areas. The State of Montana has been assured of an adequate supply of gas for many years to come, and sixty per cent of all towns having 1000 population now have natural gas within their limits. Several of the fields are not yet limited and 1932 will most certainly see an additional supply of natural gas developed.

American Association for the Advancement of Science, Pacific Division

The sixteenth annual meeting of the Pacific Division, A.A.A.S., and associated societies will be held at the State College of Washington, Pullman, June 15—18, 1932.

Fifteen scientific organizations will present separate programs touching on a wide range of subjects.

In addition to the programs of the separate societies, the following joint sessions of general interest have been arranged:

WEDNESDAY, JUNE 15

1:30 P. M. Reviews on the progress of scientific research.

Astronomy and Astrophysics—J. S. Plaskett, Dominion Observatory, Victoria, B.C.

Chemistr—J. B. Ramsey, University of California at os Angeles

Physics—W. V. Houston, California Institute of Technology, Pasadena

Animal Science—J. E. Guberlet, University of Washington, Seattle

Plant Sciences—G. J. Peirce, Stanford University, California

4:15 P. M. Motion pictures

"Oil Films on Water"—Dr. I. Langbuir

8:30 P. M. Address by the President of the Division, A. O. Leuschner, University of California

"The Astronomical Romance of Pluto"

THURSDAY, JUNE 16

9:00 A. M. Symposium on *"Scientific Problems of the Columbia Plateau"*

"Interesting Botanical Areas"—F. L. Pickett, Professor of Botany, The State College of Washington

"Geological Problems"—M. G. Hoffman, Assistant Professor of Petrology, The State College of Washington

"Economical and Agricultural Problems of the Wheat and Apple Industies"—E. F. Dummeier, Professor of Economics, The State College of Washington

"Engineering Problems"—Ivan C. Crawford, Dean, College of Engineering, University of Idaho

8:00 P. M. Address by J. Harlen Bretz, University of Chicago, *"The Scablands of the Columbia Plateau in Wishington"*

FRIDAY, JUNE 17

1:00 P. M.

4:00 P. M. Visit to the University of Idaho

8:00 P. M. Address — Professor Charles Singer, University of London.

Excursions to areas of biological and geological interest—Kamiak Butte, Almota Canyon, Moscow Mountain, Bald Butte, Snake River Canyon, Wallowa Mountains, and the Scablands have been organized.

Members proposing to attend the meeting will receive special rates for rail travel under the identification-certificate plan. The round trip fare to Pullman will be one and one-third single fares.

Progress in Oregon Geology Since 1925[1]

By EDWIN T. HODGE
University of Oregon, Eugene, Oregon

THE year 1925 divides geological investigations in Oregon into two periods—the historic, and the modern. In the historic period five great names stand for five epochs of progress in the investigation of Oregon geology.

In the epoch of discovery, the name of Thomas Condon, father of Oregon geology, stands almost all alone. His geologic writings date from 1869 to 1906, and though his publications were few, his letters were numerous, and his activities enormous. He discovered most of the salient features of Oregon geology. Though only an amateur, he had a very keen insight and drew remarkably accurate conclusions.

It was Condon who discovered, but Israel C. Russell who introduced the age of exploration in Oregon geology. For twenty-one years, from 1884-1905, he published voluminously on his reconnaissance investigations of the eastern slopes of the Cascade Mountains and eastern Oregon. The writings of no other geologist have left a deeper impression than the vivid descriptions of the geology of Oregon by Russell.

Joseph Salas Diller also belonged to the age of exploration, but in contrast with Russell carried on detailed investigations west of the Cascade Mountains and particularly in southwestern Oregon. From 1884 to 1922 or a total period of 34 years, he made the geology of Oregon vivid, interesting, and known to the rest of the world. He had produced, by 1925, the only geological maps in the state of Oregon.

Until the nineties continental deposits had not been properly correlated with marine deposits nor had those of eastern Oregon been properly correlated with continental deposits elsewhere. In 1897 John C. Merriam chose the John Day region of eastern Oregon for his important and brilliant work in vertebrate paleontology. He properly classified the old forms, discovered many new forms, and compared them both with the vertebrates of a section in California where both continental and marine types occur together. Thus he established for the first time, dependable data planes of the Tertiary formations of eastern Oregon. The horizons are not, perhaps, permanently established. Following the lead of the American Museum of Natural History of New York City or of other workers, the horizons may change slightly, but will not affect fundamentally, the data established. Ralph Chaney is now correlating the paleobotanical data with the established vertebrate horizons. It is to be regretted that other duties have taken Merriam away from Oregon. From 1916 to the present time only one paper in 1920 dealing with Oregon geology has been offered.

As early as the fifties the Blue Mountains of eastern Oregon were overrun by gold prospectors, but it was not until 1900 that they were scientifically examined by Waldemar Lindgren. From 1900 to 1910 Lindgren offered several important contributions to geology of northeastern Oregon and

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in 1925 made a detailed examination of the Baker district, though the latter has not been published.

From 1869 to 1925 Condon, Russell, Diller, Merriam, and Lindgren discovered, explored, mapped, and established many of the essential facts of Oregon geology. These early reconnaissance investigations, made under difficult conditions, formed the foundation upon which all later geological investigations have been based. Let us now turn our attention to the discoveries of the last five years.

The geological map of Oregon has undergone many changes. Instead of the great splash of red covering eastern Oregon, Washington, and Idaho indicating the presence of the Columbia River lava plateau, we now have many colors showing rocks dating from the Paleozoic down to Recent. No statement regarding Oregon geology was, perhaps, more erroneous than that Miocene olivine basalt covered all of eastern Oregon and that it lay horizontal. Eastern Oregon is neither an area of basalts nor of horizonal rocks. Each of the periods of the Tertiary have produced basaltic and other flows that make up the surface of eastern Oregon.

The geological map of the state of Oregon prepared by the writer and to be published as a part of the map of North America by the United States Geological Survey for the International Geological Congress of 1933, will bear little or no resemblance to any previously published geological map of the state of Oregon.

The progess of geological mapping in both Oregon and Washington has been lamentably slow. In fact, until 1925, the only areas mapped in detail were those by Diller in southwestern Oregon which covered less than one-thirtieth of the state. Since 1925, Hodge has mapped in north central Oregon and in the northern Cascade Mountains an additional one-tenth of the state. Recently the United State Geological Survey has published a small map of a narrow strip near the Deschutes River by Stearns. The detailed mapping of the Baker district by Lindgren and Gilluly has not been published. Thus, less than four-thirtieths of the state of Oregon has been mapped, and the scientific and economic progress of the state has correspondingly been retarded. In view of the progress made since 1925, it is evident that were funds and qualified assistance available, the balance of the state could be mapped within a period of twenty years.

The progress of detailed reports on areas within the state is behind that of detailed mapping. Nevertheless, sufficient work has been done, so that we have a fairly accurate understanding of a cross section through the northern part of the state. The investigations of the United States Geological Survey in the Blue Mountains, the classical investigations in north central Oregon made by Merriam and his four students, Buwalda, Stock, Chaney, and Packard, and the detailed mapping of north central Oregon and the northern Cascades by Hodge carry the cross-section to the Willamette Valley. The writer hopes to carry his study westward across the Willamette Valley into the Coast Range and thus complete this cross section.

Before 1925 the Cascade Mountains were considered to be formed of Miocene and early Pliocene lava flows that had been highly deformed and in late Pliocene time eroded to a peneplain. The Cascade peneplain was considered to have been elevated, eroded in the Pliocene, and glaciated. The Miocene

rocks were considered to be olivine basalts and the Pliocene rocks to be hypersthene andesites.

Later investigations have shown that the Oregon Cascade Mountains are divisible into two portions, the southern mountains are related to the Siskiyous of northern California, and the northern are related to the southern Cascade Mountains in Washington. No recent work has contributed any new facts to the southern Cascade Mountains. The northern Oregon Cascade Mountains are now known to date from Eocene to the Recent. Their older formations can be traced into eastern Oregon and into the Coast Range and only the Pliocene and later rocks are local. The Cascade Mountains, therefor, are a physiographic unit formed by a pile of lavas. The Deschutes River on the east and the Willamette River on the west subsequent to the later lavas have somewhat isolated the Cascade Mountain physiographic unit. The writer has found Eocene-Clarno forms of eastern Oregon in the Santiam Valley and Eocene Umpqua sandstones of the Coast Range in the Clackamas Valley, and these two occurrences are the oldest rocks to be found in the northern Cascades. Gently folded Oligocene pyroclastics lie unconformably on the Eocene and were little eroded before the outpouring of Miocene basalts. On the Oligocene beds lie the folded and faulted Miocene olivine-free basalts. The folds and faults differ in no way from those of eastern Oregon and were the later formations removed from the Cascade Mountains the "plateau" of eastern Oregon would extend with no fundamental change to the Willamette Valley. These Miocene basalts were never peneplained and only near buried valleys were they even eroded to the stage of late maturity. The slightly eroded Miocene basalts were buried by pyroclastics and later by the lava flows of Pleistocene age and these, in turn, by lava flows and pyroclastics of Recent age. Over large areas the Pleistocene and Recent formations may have participated in a general tilting involving almost the entire state, but nowhere has evidence been found that they have suffered local folding. They consist of olivine basalts, olivine andesites, sub-siliceous andesites, per-siliceous andesites, trachytes, and rhyolites. Hypersthene andesites are only locally developed, and not as wide spread as was formerly supposed.

Condon and Diller developed the widely held down-warped trough theory of the Willamette Valley, supposedly similar to Puget Sound, Chehalas, and the Sacramento valleys. Willamette River was consequent in this trough. A Pleistocene depression of western Oregon let the ocean invade the Willamette Trough and Columbia River. Down-warping faulted, in places, the eastern side.

Later investigations have shown Willamette Valley has no faulted areas and that the Eocene and Oligocene formations of the Coast Range dip eastward under the Miocene basalts of the Cascade Mountain area for ten to fifteen miles. This structure and erosional remnants of Columbia River basalts on the Coast Range show the Willamette Valley is a subsequent valley carved on the soft Oligocene beds; with a west wall formed by Oligocene and Eocene formations, and the eastern wall by the Miocene basalts.

Perhaps the greatest addition has been to the knowledge of the structure of the state. In 1925 the only highly folded rocks known in southwestern and northeastern Oregon. The Coast

Range was a simple anticlinal fold, the Willamette Valley a simple warp, the Cascade Mountains were suspected of being formed of folded rocks, but no descriptions of any structures existed, and eastern Oregon, except for the faulted block mountains of southeastern Oregon, was a great simple plateau formed of horizonal rocks.

Cross-sections drawn through the Coast Range by Callahan show it to be composed of a geo-anticline of gentle proportions with steep-dipping beds on the western side, some of which, according to Hodge, may be faulted. The eastern flank of this geo-anticline dips under the Cascade Mountains. Structurally, the Cascade Mountains are not independent of the Coast Range nor of eastern Oregon. The Eocene, Oligocene and Miocene beds of all three have undergone a common structural history.

The great Columbia River lava plateau has been shown by Buwalda, Packard, and Hodge to be folded and faulted and Hodge has traced many of the structures of the "plateau" westward under the Cascade Mountains. Some of the folds of the "plateau" form mountain ranges and can be traced for long distances. Thus the Ochoco Mountains are an anticlinal uplift and Hodge has traced the Grizzly anticline northeastward across Oregon from the Cascade Mountains to the Columbia River or for a distance of nearly 100 miles. The plateau also has been faulted in many places, the largest fault being on the north side of the Columbia River extending from the Cascade Mountains nearly 60 miles eastward, almost to Umatilla, and is a fault of the first magnitude. Most of the folding and faulting took place in the early Pliocene and both were eroded during the late Pliocene. As a result windows were opened up through which may be seen folded and metamorphosed rocks. In southeastern Oregon no rocks older than the Clarno-Eocene have been exposed, but in the Mutton Mountains near Ashwood, in the Ochocos, in the John Day Basin, near Canyon City, and elsewhere these windows expose rocks some of which are Palaeozoic in age. These new discoveries give us the first clew regarding the pre-lava structures and surfaces. The fault block mountains, as a result of the work of Russell, Fuller, Waters, and Smith, are now known not to be simple block faults of Miocene basalt, but expose much older rocks at their base, and are capped by formations much younger than the Miocene. In fact, the faulting seems to have been late Pliocene or early Pleistocene in age.

The stratagraphic contributions of the last few years have been exceedingly valuable. Eastern Oregon is not covered by Miocene basalts. The Miocene lava plateau lies east of the Cascade Mountains and north of the Ochoco and Blue Mountains. Hodge has shown by detailed mapping that Pleistocene basic andesites and olivine basalts occupy the entire region of the upper Deschutes, and that large areas of olivine basalt of Pleistocene age lie in southeastern Oregon. It is also strongly suspected that the basalts of the Snake River area are not Miocene in age. Many of the olivine basalts previously considered Miocene in age are of later age and the Miocene basalts are characteristically glassy, non-olivine basalts.

Two new areas of highly fossiliferous Mississippian beds have been found in Oregon by Packard. The fauna is the second Baird fauna found in the North American continent. New large areas of Mesozoic rocks have been discovered and investigated.

Schenck has proven that one of the new Triassic areas is composed of two horizons comparable to the California Triassic. The Jurassic has been thoroughly studied by Lupher, now of the Washington State College, with rather startling results. Not only has he developed a Jurassic column much fuller than that developed elsewhere in many parts of the United States, but he has found horizons not previously represented on the North American continent, but show a kinship with Himalayan faunas. This Jurassic contains the first Jurassic ichthyosaur found not only on the Pacific coast, but in North America. The western most area of Triassic found by Hodge shows evidence of having been peneplained before the deposition of the Cretaceous.

Packard has discovered and collected an exceedingly rich fauna from the Cretaceous of eastern Oregon. The fauna is rich in new material and shows a marvelous distribution of types, all of which is being prepared for a thorough monographic publication. In it Packard has discovered the first Cretaceous ichthyosaur in North America as well as the first pterodactyl to be found outside of the Niobraran sea. The evidence so far points to the fact that Oregon was so delightful that Triassic ichthyosaurs lingered there throughout the Jurassic and Cretaceous.

The Tertiary flora fascinated Condon and was made famous through the researches of Newberry, Lesquereux, and Knowlton, and lately has been subjected to scientific scrutiny and interpretation by Chaney. So far only the Eocene and Miocene have received detailed attention, but since this material is closely related to living material in various parts of the world, it is evident that future work in the Pliocene and Pleistocene will yield important results. Since the Tertiary of Oregon is largely volcanic, the establishment of stratigraphic horizons will depend largely upon paleobotanical researches. It is to be hoped that Chaney will continue his investigations and eventually establish a complete set of horizons determinable not only by leaves, but by wood as well, that will correlate with the vertebrate and invertebrate horizons of the Pacific Coast.

The original area of Clarno-Eocene found near Bridge Creek close to Clarno Ferry has since been traced by Buwalda southward in the John day country and by Hodge westward into the Deschutes canyon and into the deep canyons of several streams cutting in the Cascade Mountains. In addition, Hodge has found areas of Clarno in many parts of southeastern Oregon. The Eocene of western Oregon is now being investigated by Turner and in a few years we may expect it to be thoroughly defined, and the Eocene areas mapped.

Since the time of Dall and Diller the Coast Range of Oregon has been neglected. Their conclusions were that the Coast Range consists mainly of a mass of Eocene sandstone on the flanks of which lie Miocene beds with some Pliocene and Pleistocene formations in small patches along the coast. Schenek has thoroughly defined the marine Oligocene and shown that much of the Miocene of the Coast Range is Oligocene in age. It is to be hoped that Schenck will continue his investigations and present us with a map showing the detailed distribution of the Oligocene beds. The classical Oligocene of the John Day region described by Merriam has been traced by Hodge westward into the Cascade Mountains. Chaney has shown the

Warrendale formation to be Oligocene in age, and Hodge has been able to prove that is identical with the John Day formations of eastern Oregon and the Oligocene tuffs of the Coast Range. Perhaps the most important results of the detailed mapping of north central Oregon was the tracing westward from the John Day area of this formation into the Cascade Mountains and the discovery there of a rich upper John Day fauna which shows transition forms with the Miocene. We may now say that we have one fundamental datum plane in the state of Oregon, to wit, the John Day, which may be traced from Eastern Oregon under the Cascade Mountains and over the Coast Range.

The finished work of Turner and Schenck may make it possible to trace their horizons eastward and correlate them definitely with the continental Eocene and Oligocene of the Cascade Mountains and of eastern Oregon. Such a prospect is warranted since Hodge has shown that it is possible to trace both the marine and the continental formations into the Cascade Mountains. Were this done the leaf-bearing formations of the Cascade Mountains might be tied into a general correlation.

Willis and Diller assumed that the Pliocene poneplain which the former found in Washington extended into the Cascade Mountains of Oregon. No such peneplain, however, has as yet been found in the state of Oregon.

The Pliocene folding probably resulted from a general subsidence of eastern Oregon as proven by the fact that the Miocene basalts which must have been formed above the sea level are now in part below sea level. This subsidence of central and eastern Oregon was probably associated with an uplift of western Oregon, as shown by the fact that the marine sandstones and tuffs now stand 1,500 to 2,000 feet above sea level. Hodge thinks this evidence, along with the almost straight coast line, points to a fault along the Oregon coast with a block fault-like uplift of the entire state accompanied by a tilt to the east. If this be true, then folding did not stimulate erosion, but rather reduced its intensity, especially in the central and eastern part of the state, where the general level was lower than previously. Certain it is that Pliocene erosion never reached beyond the stage of maturity. Pliocene, being a period of erosion, has left little paleontological evidence, but Stock has described a Pliocene bear.

Reid and Sylvester have briefly described the existing glaciers in Oregon. Hodge, in the Mount Hood and Mount Jefferson regions, has found evidence of three different stages of glaciation of which existing glaciers are descendents of the last stage. Glaciation was purely local and these stages were probably contemporaneous with those in California and Washington. The stability of the Cascade Mountains during Pleistocene vulcanism points to the fact that climatic changes produced the different glacial epochs.

During the Pleistocene period lava flows have covered a large part of eastern Oregon and the entire Cascade Range has been piled up. The scenic features in Oregon are largely Pleistocene in age.

The pyroclastics of the earlier part of the Pleistocene buried the Pliocene erosion surface in the Cascade Mountain region. One of the valleys so buried was old Columbia River. Dammed by lavas Columbia River produced Condon Lake, the old shore line of which is found in Oregon at an elevation of 1900 feet and, in places, has been seen in the state of Washington.

This lake discharged westward in a consequent valley formed by the Pleistocene lavas along its present route where its course is superposed upon the older formations. The canyon of Columbia River is not an ancient antecedent course as described by LeConte, Bretz, and Williams, but has a Pleistocene and Recent consequent and supperposed course. The rise of Condon Lake to an elevation of 1900 feet caused it to invade neighboring drainage systems and capture other rivers and produce an integrated river system. The full significance of this theory has not as yet been investigated, but gives promise of answering many of the contradictions to be found in geologic reports on eastern Oregon and Washington.

Scientific investigations have kept well in advance of the economic investigations in Oregon. In fact, it may be said that except for the work done in the Baker district of the Blue Mountains, no detailed investigation of any mining district in the state of Oregon has been undertaken since the early days. The gold mining which once promised so much has almost ceased to exist. The secondarily enriched outcrops of the lode gold veins have been mined, and no basic ores of high tenor have been found. Recent reports of the United States Geological Survey show that for at least 25 years none of the known copper prospects in Oregon can be mined at a profit. During the war manganese was boosted and before the war the nickel deposits at Riddle were considered a possible industry, but both lie neglected today. The former Oregon Bureau of Mines and Geology recommended the development of the lateritic iron ores of Columbia County, Oregon, but the lack of any suitable coke and coal, and competition of cheap pig iron from the Birmingham district make their development, even in a small way, impossible. About 1925 Hodge called attention, in a series of articles, to the fact that Oregon provides a natural environment for cinnabar. Since that time a number of mines have been developed, some of which are paying, at the present time, handsome dividends.

Coal occurs in the Eocene of eastern and western Oregon and the Marshfield area may be developed to serve a local market. Over fifty holes have been sunk in Oregon in the exploration of oil and gas. Only three of these have been located as a result of previous geological investigations and as a result only three are located where there is even a remote possibility, either by reason of structure or formation, to justify the expectation of finding oil. Certain sedimentary marine bads in Oregon deserve prospecting, but up to date none of them have been drilled. Lenticular limestone beds in the Coast Range are quarried for cement and land plaster. The large deposits in eastern Oregon are not developed and are far from transportation.

Waring's investigations of the ground water possibilities of southeastern Oregon are the only detailed investigations of our most important economic problem. Numerous important and successful studies of dam sites have been made and since 1925 the record is clear of dam and irrigation failures due to neglect of geological conditions.

The writer has attempted briefly to give an historic picture of the progress of Oregon geology. The record up to 1925 is recorded in Dixon's thorough and reliable Biography. Below the writer appends a bibliography complete up to date of the paper of all publications on Oregon geology since 1925.

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Some Phases of Cenezoic Geology in East-Central Oregon[1]

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THE Paleozoic-Mesozoic rock area of central Oregon is encircled by continental formations that appear to represent much of Cenezoic time. The most complete Cenezoic section known in this region is found along the east margin of the old-rock area and lies on the south side of the Ochoco Range and on the Silvies Plateau between Canyon City and the Crown Flat ranger station. The narrow westward-trending Ochoco Range forms a distinct geographic separation between the classic Cenezoic section of the John Day Basin and that of the Silvies Plateau.

The Cenezoic rocks of the Plateau lie upon and intrude a basement of highly folded Triassic and Jurassic marine sedimentary rocks and continue north beyond the margin of the Triassic pyroxenite (serpentine) and Jurassic gabbro that forms this part of the Ochoco Range. Geologic mapping has shown that the Cenezoic rocks comprise 16 divisions of sediments, lavas, pyroclastics, and intrusives. Only one fossiliferous formation has been found in the plateau, but the geologic evidence indicates that correlatives of all the John Day Cenezoic formations are to be found here. The remaining divisions appear between the John Day correlatives and show abundant unconformable and intrusive contacts, thus presenting some additions to the known Cenezoic sequence of eastern Oregon.

[1]Abstract of paper presented at the Annual Meeting of the Northwest Scientific Association, December 29-30, 1931, Spokane, Washington.

A Tentative Correlation of Northwestern Tertiary Strata[1]

By

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University of Idaho[2]

INTRODUCTION

THIS paper is an attempt to correlate the Tertiary strata of the Northwest.

Information is scarce and descriptions incomplete on most sections of the State of Idaho. Very little of the material is recent, and there are many minor discrepancies in the age determination of several of the formations, but as a whole they carry through quite well. Data on the Miocene seems to be the most complete of any of the sections. Age determinations have been based upon fossils where fossils are present, otherwise, the determination has been based upon lithologic character and general stratigraphic relationship.

For convenience, the area covered in this paper has been divided into eleven sub-areas following the boundary of Idaho from the Yellowstone Park south to Utah, west to Oregon, and north through Washington to British Columbia.

An attempt has alse been made to correlate the formation of the Idaho areas with those occurring along the Pacific Coast in Washington, Oregon, and California. The correlation on the Pacific Coast region is unsatisfactory as there seems to be a great difference of opinion in the names and ages of the various formations. The formations west of the Cascades are chiefly of marine origin, and consequently are difficult to correlate with continental formations of the interior.

*Yellowstone Park**

Tertiary formations in the Yellowstone Park area consist of approximately 11,000 feet of undifferentiated lava flows and breccias of Pliocene, Miocene and Eocene ages, together with intercalated sedimentary strata in the Pliocene and ower Eocene. The Pliocene strata comprise the Tower Creek (Canyon) conglomerate, and the Lower Eocene the Pinyon conglomerate. The latter rests unconformably on the early acid breccias and lavas.

Southwestern Wyoming[1] and Northeastern Utah[10]

Pliocene, Miocene, and Oligocene formations are absent in the southwestern Wyoming area, but a nearly complete Eocene column is present.

The Bridger formation, varying in thickness from 0 to 1,800 feet, and consisting of greenish sandstone and shale, much volcanic ash, and white beds, is at the top of the Eocene column. It rests uncomfortably on the Green River formation.

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[1]Presented at the Annual Meeting of the Northwest Scientific Association, December 29-30, 1931, Spokane, Washington.

[2]Accepted as a thesis in partial fulfilment for the degree of Master of Science in Geology in the School of Mines, University of Idaho, 1932.

The author herewith acknowledges almost continuous assistance and guidance received from staff of the Department of Geology during the studies for and in the preparation of this manuscript.

He also gratefully acknowledges assistance from Dr. Warren DuPre Smith, Head, Department of Geology, University of Oregon, in studies of the stratigraphy of Oregon. He is also indebted to Mr. Thomas H. Hite for a very helpful list of literature.

*Numbers refer to publications as listed in the biography.

The upper member of the Green River formation consists of about 1,200 feet of calcareous shale and some light colored sandstone. The lower member of about 800 feet of light colored limestone.

Unconformably underlying the Green River formation is the Wasatch group, which in the southwest Wyoming area is about 4,000 feet thick, and which is divided into three major divisions, the Knight, the Fowkes, and the Almy members respectively. The Knight formation is the upper member of the Wasatch group and is composed of 500 to 1,750 feet of red and yellow sandy shale and sandstone with some concretionary limestone. The Fowkes formation is the middle member of the group and consists of 0 to 2,500 feet of volcanic ash of white beds with intercalated limestone. The lower member, known as the Almy formation, varies in thickness from 2,100 to 2,500 feet, and consists of red and yellow sandstone and shale at the top and a conglomerate at the base.

Immediately below the Wasatch is the Evanston formation with a variable thickness of 0 to 9,500 feet. The Evanston has not been divided, and consists of gray, yellow, and black shale, and yellow sandstone, and contains some coal. This formation is separated from the Cretaceous by a marked unconformity.

Northern Utah has a nearly complete and well divided Eocene column at the top of which is the Uinta formation, a series of conglomerates, sandstones, and shales. The total thickness of this formation varies from 500 to 1,000 feet. The Washakie formation, which occurs below the Uinta, is also of Upper Eocene age and is composed of 200 feet of sandstone and shale. The Bridger formation, of Middle Eocene age, lies below the Washakie and consists of a fine conglomerate, heavy bedded sandstone, and shale with some thin layers of white limestone, the whole formation totaling 600 to 1,000 feet in thickness. The Green River formation, of Middle and Lower Eocene age, is made up of 2,000 feet of calcareous shale, and thin-bedded limestone. The shale and limestone are locally bituminous and have a gray color. The Wasatch formation in this region is below the Green River formation and is composed of 1,000 to 1,500 feet of heavy-bedded conglomerate and sandstone.

Southeast Idaho

Upper Snake River Section[1a, 3]: The upper Snake River section consists of the area drained by the headwaters of the Snake River (including the Fort Hall Indian Reservation) and contains Pliocene or Miocene and Eocene rocks. The youngest beds in this section are exposed along Birch Creek and consist of some 5,000 feet of loosely consolidated gravels of Pliocene age. Below these gravels are found lavas and basal basalts of Middle and Upper Pliocene age.

On Medicine Lodge Creek are 1,000 to 2,000 feet of lake bed deposits of Lower Pliocene and Upper Miocene age. These consist of sandy shale, dark shale, sandstone, conglomerate, and lignite. The same beds occur again on Wet Creek and are made up of shale, sandstone, conglomerate, lignite, and tuff. The lower parts are interbedded with the early Tertiary lavas of which there are approximately 5,000 feet. The Pliocene age of these deposits may be questioned. More recent determinations indicate that these deposits are probably of Upper Miocene age and should correlate with the Salt Lake formation which is found farther south and which has recently been assigned to the Miocene.[38]

The Wasatch formation, which is Eocene in age, lies beneath the last mentioned Tertiary lavas. It consists of 1,500 feet of coarse red conglomerate containing pebbles or boulders that range from one inch to three inches in diameter. The Wasatch formation in this section has not been subdivided.

PORTNEUF-BEAR LAKE SECTION[2, 4, 5, 6, 9, 38]: The Salt Lake formation is composed of 750 feet or more of conglomerate, white marl, calcareous clay, sandstone, grit, and volcanic ash, with locally intercalated limestone.

Although most of the earlier writers have placed the Salt Lake formation in the Upper Pliocene, information only recently made available indicates that the formation is probably of Upper or Middle Miocene age. (Geology and Mineral Resources of Eastern Cassia County, Idaho, by A. L. Anderson. Bull. 14, Idaho Bureau of Mines and Geology, p.44. September, 1931).

Below the Salt Lake and separated from it by a major unconformity is the Wasatch group of Eocene age. This group has been subdivided into two major members in the Portneuf-Bear Lake section, the upper being called the Knight formation and the lower the Almy formation. The Knight formation comprises 500 or more feet of red and yellow sandy clay, sandstone, and concretionary limestone, and is underlain unconformably by the Almy formation, which consists of 1,000 feet of red and yellowish white conglomerate, sandstone, and sandy clay.

South Central Idaho and Northern Utah[7, 10]

The area which has been termed South Central Idaho and Northern Utah is that area included in Cassia, Power, and Oneida counties in Idaho, and several counties in Utah.

On Trapper Creek, in Cassia County, Idaho, there are exposed lacustrine deposits and intercalated flows of probable Upper and Middle Miocene age with an aggregate thickness of 1,700 feet. The beds consist principally of volcanic materials such as ash and rhyolite flows, separated by beds of ash. A few beds of lignite and carbonaceous shale occur in the lower part of the formation. At the base of the Miocene is the Bluff Creek rhyolite, which is a massive blue-gray to buff-brown rhyolite, aggregating more than 1,000 feet in thickness. These unnamed beds of Miocene age have recently been cited as equivalent to the Salt Lake formation. [38]

Southwest Idaho and Northern Nevada [8, 11, 14, 15]

The southwest Idaho and northern Nevada area includes Owyhee and Twin Falls counties in Idaho and an area in northern Nevada adjoining the Idaho line. One thousand feet of undifferentiated, dark colored, olivine-bearing basalt of Upper Pliocene age top the stratigraphic column in this area. Immediately below the basalt is the Humboldt formation of Nevada, which consists of friable gray, white, and dark sandstone, and marly limestone. It contains some volcanic material of rhyolitic character and has been determined as Middle or Upper Pliocene in age. The Humboldt may have a thickness of 800 feet or more.

Exposed in Idaho and correlated with the Nevada Humboldt is the Idaho formation of somewhat similar character. It is made up of 500 to 1,000 feet of fine-grained sand, shale, and conglomerate. There has been some disagreement as to the exact age of this formation, but it is most generally assumed to be of Middle and Upper Pliocene age.[11, 19] Both the

Humboldt and the Idaho indicate lacustrine deposition.

At least 2,000 feet of undifferentiated rhyolite of Upper Miocene or Lower Pliocene age separate the Humboldt from the Truckee group of lake beds. The Truckee group of Nevada is of unmeasured thickness and contains much volcanic debris of rhyolitic nature. The group has been assigned to the Middle Miocene. In the Idaho area 2,500 to 3,500 feet of basalt and rhyolite separate the Idaho formation from the Payette formation of Middle and Lower Miocene age. The Payette formation extends into Nevada beneath the Truckee group and is composed of lacustrine deposits 50 to 800 feet in thickness and will be described more completely in the next section.

The lower part of the Payette is interbedded with the Owahee basalt of Lower Miocene age and of which there are 1,200 to 1,500 feet in this area.

Deposits of tuffaceous conglomerate, arkosic sand, sandy shale of a buff and light brown to green color, rest at the top of the Eocene and extend upward into the Oligocene.

Below these tuffaceous beds is a series of lake beds more than 700 feet thick, consisting of well stratified, fine-grained, calcareous and siliceous shale. This series is also of Eocene age. At the base are basalts, rhyolites, and diabasic basalts with an aggregate thickness of 2,200 to 5,000 feet.

West Central Idaho

Snake River, Payette, and Weiser Valleys [6, 16, 17]: The area termed Snake River, Payette, and Weiser Valleys includes that part of the region drained by the Snake River in western Idaho and the valleys of the Payette and Weiser rivers in west central Idaho. Basalt occurs at the top of the geologic section. It has a thickness of 15 to 50 feet along the Snake River, but thickens to over 1,000 feet in the upper Peyette Valley.

Below the basalt is the Idaho formation of Middle and Upper Pliocene age. The Idaho formation consists of lake bed sediments very similar to the Payette of which it may possibly be a later phase.

The Poison Creek formation occupies a place immediately below the Idaho and above the Payette, and is composed chiefly of ash, clay, sandstone, and shale, and is very similar to the final stages of the Payette. It is of ower Pliocene age.

The Payette formation is of Middle and Upper Miocene age and has a thickness of 1,000 feet in the Payette and Weiser valleys. The formation is composed of lake bed deposits similar to those which characterize the Poison Creek and Idaho formations. The lower part of the formation is interbeded with the Columbia basalt. These lavas reach a thickness of more than 4,000 feet in the area.

Kirkham describes the Owyhee rhyolite between the Payette and Idaho formations. He does not recognize the Poison Creek formation.[39, 40]

Boise River and Boise Basin[18]: Undifferentiated basalt and rhyolite of unmeasured thickness are the uppermost Tertiary strata in the area covered by the Boise River and the Boise Basin. These have been assigned to the Pliocene. The stratigraphic column in this section is similar to the column just described in the previous section. The Idaho formation is found below the basalt and rhyolite. Beneath the Idaho is the Poison Creek formation. Flows of rhyolite and basalt of Upper Miocene age separate the Poison Creek formation from the Payette.

The Payette formation in this section is of a character similar to that described in the preceding section. It has a thickness of 200 to 1,000 feet, is definitely of Middle Miocene age, but may extend into the Upper Eocene.

Eastern Oregon

JOHN DAY VALLEY[19]: Lava flows, composed principally of basalt and underlain by the Idaho beds, comprise the Upper Pliocene formations in the John Day Valley. The Ironsides beds, which lie below the Idaho formation, are of Middle Pliocene age and are made up of a buff, sandy shale. The Rattlesnake formation which occurs beneath the Ironside beds, is composed of 100 feet of tuff and gravel beds, and of rhyolite flows. The Mescall formation, composed of tuff, ash and gravel, is of Upper Miocene age. Beneath the Mescall are the Columbia lavas which are olivine basalts and tuffs with intercalated gravel. These lavas are of Middle and Lower Miocene age. The Warrendale formation, occurring below the Columbia basalt, consists of carbonaceous clay and tuff. The John Day formation covers the whole of the Oligocene column and extends up into the Lower Miocene. The beds are composed of tuffs, sands, gravels, and rhyolites.

The correlation table accompanying this paper places the Payette formation of this region in the Upper Eocene. The writer used an article published in 1924 by Dr. W. D. Smith of the University of Oregon in which he stated that the Payette formation was of Eocene age. However, a recent personal communication from Dr. Smith states that the formation should be placed in the Middle and Lower Miocene.

The Clarno formation of Lower Eocene age consists of shale, ash, tuff, and rhyolite and andesite flows. This formation is the lowest Tertiary exposed in the area.

SOUTHEAST LAKE DISTRICT[22], [23]: The only Pliocene formation exposed in the southeast lake district, Oregon, is 20 to 50 feet of basalt.

The Grassy Mountain basalt is an olivine basalt of Upper Miocene age, and has a thickness of 400 or more feet in the southeast lake district of Oregon. The Payette formation, together with intercalated Columbia basalt, also occurs in this region. Below is the Alvard formation of Lowar Miocene age which is composed of 1,000 feet of coarse tuffs. Beneath the Alvard is the Trout Creek formation of Lower Miocene age. This consists of a fine white ash. Contemporaneous with it is the Owyhee basalt. The latter attains a thickness of 1,300 feet.

The Eocene column is divided into two formations: The upper or Coyote, which is composed of older andesite, rhyolite, and andesitic tuff, and the lower or Wagon Tire rhyolite. The Coyote formation is of questionable Eocene age.

Seven Devils[30] and Thunder Mountain[31]

The Tertiary formation exposed in the Seven Devils region is the Columbia basalt, which in a few places is intercalated with the Latah formation. The Columbia basalt varies from 100 to 4,000 feet in thickness. Farther east in the Thunder Mountain region older rocks are exposed. A verbal communication from Mr. D. C. Livingston, who was a member of a field party engaged in a study of the geology and ore deposits of the Yellow Pine quadrangle, Idaho, under the supervision of the U. S. Geological Survey during the summer of 1931, states that the following formations were found:

PACIFIC COAST — Generalized Section 36, 37		
Washington	**Oregon**	**California**
	28. Elk River.—Black sands.	**28.** Saugus.
27. Quillayute fm. Ss., bluish gray sh. Cgl.	**28.** Empire beds. Cgl., ss., sh.	**28.** Etchegoin
27. Quinaielt fm. Cgl., sh., ss.		**27.** Purisima
41. Montesano fm. 5000′+or—.	**28.** Astoria fm. Sh.	**28.** Monterey
	28. Aturia bed. Sh.	**28.** Temblor
41. Chehalis fm. 7000′ + or —.		
41. Wahkiakum fm. 8000′ + or —		
27. Tunnel pt. beds, Sh., ss. **27.** Blakely fm. 9000′+or—. Sh., ss., cgl.	**28.** Nye Shale.	**27.** San Lorenzo (Porter)
	28. Eugene fm.– Tuffs, ss. with basalt dikes and sills.	
27. Greece Ranch fm. Lincoln beds. Porter beds.	**28.** Toledo fm. Tuffs, ss. Basalt dikes and sills.	**27.** San Emigdio. San Lorenzo.
27. Puget Series, 10000′. Sh., and ss.	**27.** Wilbur tuff lentils. Thin.	**27.** Marysville Buttes.
	27. Umpqua fm. 12000′. Thin bedded ss. and sh.	**27.** Meganos
	27. Tyee fm. ss. Some fresh water.	**27.** Upper Tejon
27. Crescent fm. Black to green basalt. Tuffaceous sands.	**27.** Arago.	**27.** Tejon
Note: 43. The Hoh formation has recently been placed in the Miocene.		

A TENTATIVE CORRELATION OF NORTHWESTERN TERTIARY STRATA

COMPILED BY JOHN TYER CARPENTER, IDAHO SCHOOL OF MINES—1931-1932

AGE

PLIOCENE: Upper, Middle, Lower
MIOCENE: Upper, Middle, Lower
OLIGOCENE: Upper, Middle, Lower
EOCENE: Upper, Middle, Lower
PRE-EOCENE

YELLOWSTONE PARK

1. 11000′ Lava flows, Breccias and Intrusives.

tower cr. (Canyon) congl.

1. Pinyon Cgl.

1. Early acid breccias and lavas.

SOUTHWEST WYOMING and NORTHEASTERN UTAH

1., 10 Bridger fm. 0′–1800′ Greenish sand and sh. largely volc. ash; white beds.

1. Gr. Riv. fm.: 1200′. Thin bedded Calc. Sh., some ss. Light colored. / 800′. Light colored L.S.

1. Wasatch Group: Knight fm. 500′–1750′ Red and yellow sandy Sh. and sss. Some conc. Ls. / Fowkes fm. 0′–2500 + or −′. / Volc. ash or white beds; Ls. layers. / Almy fm. Red and yellow sss. and sh. / Cgl. at Base

1. Evanston fm. 0′–9500′. Gray, yellow and black Sh., and yellow ss. Some coal.

SOUTHEAST IDAHO

Upper Snake River

1a. 5000′. Birch Creek. Gravels — consolidated and roughly stratified Black chert, Pink quartzite.

Late Lavas. Basal Basalts.

1a. 1000′–2000′. Medicine Lodge Cr. Lake beds, sandy sh., dark sh., lignite, ss., cgl. Brown to yellow. Wet Cr. Sh., Ls., ss., cgl., Lig. tuff, interbedded with Tertiary lavas. Pliocene (?)

38 ?

1a. 3000′ Early Lavas.

38 ?

3. Wasatch fm. 1500′ + or − Coarse red cgl. with pebbles or boulders that range from 1″ to 3″ in diam. Largely sub-angular fragments of Paleozoic L.s.

Portneuf and Bear Lake Section

4, 5, 6, 9. Salt Lake fm. 750′ + or −. Cgl., white marl, calc clay, Ss., grit, volc ash, few areas of Ss. and Ls.

38. Salt Lake fm.

Also Salt Lake fm.

2. Wasatch Group: Knight fm. 500′ + or − Red and yellow sy. clays, sh., ss. and concrecionary Ls. / Almy fm. 1000′ + or − Red and yellowish white cgl., ss. and sandy clays.

SOUTH CENTRAL IDAHO and NORTHERN UTAH

7. Basalt 100′ + or − (Pliocene?) Rhyolite and trachyte.

7. Trapper Cr. Lake beds. Volcanic matter, ash, rhyolite flows separated by ash.

7. 1700′ + or −. Beds vary from purely volc. to semi-sed. Some beds of Lignite and Carbonaceous sh.

7. 1000′ + or −. Bluff Cr. Rhyolite. Massive blue gray to buff brown.

SOUTHWEST IDAHO and NORTHERN NEVADA OWYHEE RIVER

15, 8. 1000′ + or −. Basalts. Dark colored, olivine bearing. Dense and glassy to highly vesicular.

15. Humboldt fm. 800′ + or − Friable, gray, white and drab ss. and marly Ls. Contains volc. material of Rhyolitic character (?)

11, 14, 8. Idaho fm 500–1000′ Fine grained ss. & sh., cgl.

8, 15. 2000′ + Rhyolite

15. 1500′ Basalt

15. Truckee Grp. Lake bed dep. Much debris of Rhyolite char.

15. 1000′–2000′ Rhyolite

14. Payette fm. 50′–800′.

14. Owyhee Basalt. 1200′–1500′.

14. Tuffaceous cgl. Arkosic sand. Sandy sh. buff, light brown to green.

11, 15. Lake beds: 700′ + or −. Fine grained well stratified. Thin sh. calc. to sil.

11. Basalts

11. 1200′–2000′. Rhyolites.

11. 1000′–2000′. Diabasic Basalts

WEST CENTRAL IDAHO

Snake River, Payette and Weiser Valley

17. Basalt. Normal feldspar basalt. 15′–50′. 1000′ in upper Payette Valley.

Idaho fm. Fresh water. Lake bed sediments.

Similar to Payette.

16. Poison Cr. fm. Ash, clays, ss., sh. Similar to Payette.

16, 17. Payette fm. 1000′. Fresh water. Lake bed material. Qz sands. Small mica flakes. Thin strata of clays. Light area, buff to nearly white in color. Cgl. thin, rare lig. st.

6. 4000′. Intercolated Basalts. Columbia Lavas.

Note: 39, 40. Kirkham includes the Payette and does not Creek formation.

Boise River and Boise Basin

18. Basalts and Rhyolites. Unmeasured thickness.

18. Idaho fm. Fresh water lake bed sediments. Similar to Payette.

Poison Cr. fm Ash, clays, ss., sh. Similar to Payette

18. Extrusive flows. Rhyolites and Basalts.

18. Payette fm. 200′–1000′. Lacustrine deposits with lavas.

(?)

Owyhee Rhyolite above recognize the Poison

EASTERN OREGON

John Day Valley

Lava flows; basalts, etc.

19. Idaho beds: —Sands, gravels, clays.

19. Ironside beds: Buff sandy sh.

19, 21. Rattlesnake fm. 100′+. Tuffs, gravels and rhyolitic flows.

19. Mescall fm. Tuffs, ashs, gravels. (?)

19. Columbia Lavas. Olivine basalts, tuffs, intercolated with gravels.

19. Warrendale fm Carb. clays and tuffs.

19. John Day fm. Tuffs, sands, gravels. Rhyolites —red, green, white.

19. Payette fm. Lacustrine deposits. Unmeasured thickness.

Note: A private communication from the author of the pamphlet states that the Payette formation is of middle Miocene Age. 4/12/31

19. Clarno fm. Sh., ash, tuffs. Rhyolite and andesite flows.

S. E. Lake District

23. 20′–50′ + Basalt flows.

22. 400′ + or − Grassy Mtn. Basalt. Olivine Basalt.

23. Columbia lavas.

22. Payette fm. Lacustrine deposits with intercolated lavas.

23. 1000′. Alvord fm. Coarse tuffs.

23. Trout Cr. Fine white ash.

22. 1300′ + or − Owyhee B.S.

23. Coyote fm. (Eocene?) Older andesites. Rhy. and andesitic tuff.

23. Wagon Tire Rhyolite.

SEVEN DEVILS and THUNDER MOUNTAIN

30. 100′–2100′ + or − Columbia Basalts. Intercolated with Latah beds at a few places only.

31. Basalt Miocene (?)

Dewey Tuffs 1500′

Clay Gouge 75′–200′

Thunder Mtn. Rhyolite. (Challis Volcanics?)

(?)

Note: Numbers refer to publications as listed in bibliography.

NORTHWEST IDAHO and EASTERN WASHINGTON

24, 25. Basalt flows intercolated with Latah fm.

24, 25. 1500′. Latah fm. Lacustrine dep. Sh., clay; few layers of sand and gravel. Color, pale yellow to lead gray.

42. Andesites and Latites

CENTRAL WASHINGTON

32 Republic Area

Basalt 25′–100′ / Later Andesite 1000′–2000′ / Trachyte flow 10′–75′ } Age Unknown

Lake beds 750′

Earlier Andesite flow Breccia 1000′ + or −

Dacite flow Conglomerate Age Questionable.

Rests uncomfortably on Paleozoic

33 Ellensburg Area

Ellensburg Ss. (upper part)

Wenas Basalt 20′–200′

Ellensburg Ss. (lower part)

Yakima Basalt. 2000′ + or −

Manastash fm.

34 Mount Stuart Area

Rhyolite Age doubtful

(?)

Ellensburg Ss. 700′–1600′

Yakima Basalt 1000′–2000′

Taneum Andesite 200′–300′

Manastash fm. 200′ + or −.

Roslyn Ss. 3500′ + or −.

Teanaway Basalt 300′–3000′ +.

Swauk fm. 3500′–5000′

35 Snoqualmie Area

Howson Andesite 250′

(?)

Ellensburg Ss. 200′

Keechelus fm. 0–4000′

Yakima Basalt 1500′ + or −

Guye fm. 3500′ + or − Age doubtful

Taneum Andesite 0–1000′

Manastash fm. 0–400′

Roslyn Ss. 3000′ + or −

Teanaway Basalt 4000′ + or −

Kachess Rhyolite 0–2000′ + or −

Naches fm.

Swauk fm. 200′–5000′.

PACIFIC COAST — Generalized Section 36, 37

Washington	Oregon	California
	28. Elk River—Black sands.	**28.** Saugus.
27. Quillayute fm. Ss., bluish gray sh. Cgl.	**28.** Empire beds. Cgl., ss., sh.	**28.** Etchegoin
27. Quinaielt fm. Cgl., sh., ss.		**27.** Purisima
41. Montesano fm. 5000′ + or −.	**28.** Astoria fm. Sh.	**28.** Monterey
	28. Alturia bed. Sh.	**28.** Temblor
41. Chehalis fm. 7000′ + or −.		
41. Wahkiakum fm. 8000′ + or −		
27. Tunnel pt. beds, Sh., ss. / **27.** Blakely fm. 9000′ + or − Sh., ss., cgl.	**28.** Nye Shale.	**27.** San Lorenzo (Porter)
27. Greece Ranch fm. Lincoln beds. Porter beds.	**28.** Eugene fm.—Tuffs, ss. with basalt dikes and sills. / **28.** Toledo fm. Tuffs, ss. Basalt dikes and sills.	**27.** San Emigdio. San Lorenzo.
27. Puget Series, 10000′. Sh., and ss.	**27.** Wilbur tuff lentils. Thin. / **27.** Umpqua fm. 12000′. Thin bedded ss. and sh. / **27.** Tyee fm. ss. Some fresh water.	**27.** Marysville Buttes. / **27.** Meganos / **27.** Upper Tejon
27. Crescent fm. Black to green basalt. Tuffaceous sands.	**27.** Arago.	**27.** Tejon
Note: 43. The Hoh formation has recently been placed in the Miocene.		

At the top of the column are basalt flows unconformably overlaying 1,500 feet of tuffaceous beds in which certain included fossils have been determined by Mr. Thomas R. Ashlee of the University of Idaho as Oligocene in age. Below these tuffs there are 75 to 200 feet of clay gouge. Underlying the gouge are rhyolite flows of unknown thickness.

Northwest Idaho and Eastern Washington[24, 25, 42]

Northwest Idaho and eastern Washington are lacking in exposures of Pliocene and Eocene rocks. The Miocene is represented by the Columbia basalt and intercalated Latah formation. The latter is chiefly lacustrine, shales, and clays with a few layers of sand and gravel, which in places reach thickness of 1,500 feet.

Some andesites and latites have been found recently in this area which lie unconformably beneath the Columbia basalt.[42] It is probable that these lavas, and those of Thunder Mountain (Oligocene), may be correlated with the Challis volcanics which have heretofore been considered to be of Miocene age. (Geology and Ore Deposits of the Seafoam, Alder Creek, Little Smoky, and Willow Creek Mining Districts, Custer and Camas Counties, Idaho, by Clyde P. Ross. Idaho Bureau of Mines and Geology Pamphlet 33, 1930.)

Central Washington

Republic Area[32]: The top of the column in this area presents three formations whose exact ages are unknown; however, they rest upon lake beds of Lower Miocene age.

The uppermost of these formations is a single flow of basalt 25 to 100 feet thick. An erosion interval is indicated between this and the next lower formation known as the Later Andesite. The latter is composed of seven separate flows of andesitic material totaling 1,000 to 2,000 feet in thickness. Lying immediately below this andesite, and interbedded with the Miocene lake beds, are two flows of trachyte 10 to 75 feet thick.

The Lower Miocene lake beds are composed of finely laminated sandstones, shales, and tuffs. All materials are predominantly fine-grained, and tuffaceous material constitutes over one-half of the total. The fine lamination of these beds point to deposition in quiet water. These sediments total 750 feet in thickness, are fossiliferous, and are grayish-brown in color.

A formation known as the Earlier Andesite Flow Breccia, consisting of 1,000 feet of agglomerate and flow breccia, lies beneath the lake beds. It is also considered to be Lower Miocene in age. At some places the breccia is stratified, and is half indurated sand with igneous boulders up to seven or eight feet in diameter. In other places the material is a firm andesite.

A dacite flow conglomerate assumed to be of Oligocene age lies beneath the Earlier Andesite, and is separated from it by an unconformity. This formation is made up of lava flows which have picked up great quantities of stream gravels derived from the underlying Paleozoic formations.

Ellensburg Area[33]: Pliocene formations are absent in the Ellensburg area.

The Ellensburg sandstone of Upper Miocene age tops the stratigraphic column. This formation contains abundant plant remains and is made up of fluviatile deposits consisting of stratified silt, sand, and gravel derived from volcanic rocks. The formation is divided into two similar parts separated by the Wenas basalt, which comprises

two or three flows totaling 20 to 200 feet in thickness. This basalt is similar in character to the Yakima basalt. The Ellensburg formation has a total thickness of 1,600 feet.

Below the Ellensburg formation are approximately 2,000 feet of Yakima basalt. The basalt series consists of ten or more separate flows and has been assigned to the Middle and Lower Miocene.

Underlying the Yakima basalt, and separated from it by an unconformity, is the Manastash formation of Eocene age. This formation is made up of sandstone and conglomerate of an unknown thickness. It contains an Eocene flora.

Mount Stuart Area[34]: The Column in the Mount Stuart area is topped by a rhyolite of uncertain age, but which at the present is assigned to the Pliocene.

The Ellensburg formation, which has previously been described, lies beneath the rhyolite and has a thickness of 700 to 1,600 feet.

Lying unconformably below the Ellensburg is the Yakima basalt from 1,000 to 2,000 feet thick. It is here assigned to the Middle Miocene.

Underlying the Yakima basalt is the Taneum andesite, which ranges in thickness from 200 to 300 feet. This formation includes some tuffs and breccias.

Formations of Oligocene age are lacking throughout most of central Washington.

Below the Taneum andesite lies the Manastash formation of Upper Eocene age. This formation is composed of 200 or more feet of sandstone and shale. The sandstone in some places is massive and quartzose while the shale is fine-grained and contains seams of bone and impure coal. Some horizons are fossiliferous.

The Roslyn sandstone lies below the Manastash and is composed of 3,500 feet of massive sandstone, some shale, and a little conglomerate. The formation yields fossils of Eocene age.

Three hundred to 5,000 feet of basalt, known as the Teanaway basalt, separates the Roslyn from the underlying Swauk formation.

The Swauk is the earliest known Tertiary formation in the central Washington area, and rests unconformably on pre-Tertiary sediments. The formation is composed of 3,500 to 5,000 feet of conglomerate, sandstone, and shale. The conglomerate is confined to the lower portion of the series, whereas the shale is interbedded with the conglomerate and sandstone. The shale is black and decidedly carbonaceous and contains numerous fossiliferous horizons.

Snoqualmie Area[35]: In the Snoqualmie area the Howson andesite of doubtful Pliocene age is at the top of the column. There are no other Pliocene formations. The rest of the column corresponds very closely to that in the Mount Stuart area with the exception of a few additional formations.

The Keechelus formation, which is composed of 0 to 4,000 feet of andesite and associated tuff and braccia (the pyroclastics being considerably more abundant than the lavas), lies between the Ellensburg formation and the Yakima basalt. It is therefore of Miocene age.

The Guye formation, lying above the Taneum andesite and below the Yakima basalt, is a sedimentary series comprising 3,500 feet of shale, sandstone, grit, conglomerate, and a little limestone and chert. The formation is fossiliferous and is considered to be of Lower Miocene (?) age.

Below the Teanaway basalt is the Kachess rhyolite, which ranges in thickness from 0 to 2,000 or more feet. It is of Eocene age.

Underlying the rhyolite and overlying the Swauk is the Naches formation, a semi-sedimentary series composed of an unknown thickness of gray sandstone and olive-colored shale with contemporaneous flows of basalt and basaltic tuff. The basalt increases toward the top of the formation and is similar in character to the Tertiary basalt. The Swauk formation underlies the Teanaway formation. Its position is at the base of the Eocene.

Pacific Coast

The formations found on the Pacific Coast differ from those in the inland area. The coast formations are of marine origin. The correlation table accompanying this paper shows some of the relations which may exist between the Pacific Coast and the inland areas.

WASHINGTON[27, 41, 42]: The Quillayute formation, deposited during the Middle Pliocene period, forms the top of the Tertiary column in the coastal area of Washington. It is composed of unknown thickness of sandstone, bluish-gray shale, and conglomerate.

Below the Quillayute lies the Quinaielt formation of Lower Pliocene and Upper Miocene age. It also is composed of conglomerate, shale, and sandstone. The Montesano formation is also of Upper Miocene age, but lies below the Quinaielt. This formation comprises 5,000 feet of marine sediments.

Middle Miocene formations are absent.

The Lower Miocene is represented by the Chehalis and the Wahkiakum formations, the Chehalis lying directly above the Wahkiakum. The former has a thickness of 7,000 feet and the latter 8,000 feet.

The Hoh formation, which has heretofore been considered to be of Jurassic age, has recently been determined to be of Miocene and Oligocene age.[43]

The Oligocene epoch on the Pacific Coast has been studied with considerable care and the formations have been separated in most of the area into several divisions. The Tunnel Point bads of Upper and Middle Oligocene age are composed of shale and sandstone. The Blakely formation, also of Upper Oligocene age and contemporaneous with the Tunnel Point beds, consists of 9,000 feet of shale, sandstone, and conglomerate.

The lower Eocene has been divided into the Greece Ranch formation, the Lincoln beds, and the Porter beds, all composed of shale, sandstone, and conglomerate.

The Puget series includes all the formations of Upper Eocene age on the Washington coast. This series is made up of 10,000 feet of shale and sandstone. Beneath the Puget series lies the Crescent formation of Middle Eocene age. It consists of black to green basalt with interbedded tuffaceous sands.

OREGON[28]: The Upper Pliocene in the coastal area of Oregon is represented by the Elk River formation. It is composed of loosely consolidated black sands. Beneath it are the Empire beds, comprising a series of conglomerates, sandstones, and shales. This lower formation is of Middle Pliocene age and may be correlated with the Quillayute formation of Washington. Formations of Lower Pliocene age are missing or remain unidentified on the Oregon coast. The Quinaielt of Washington, which is of

this age, may perhaps be correlated with the Purisima of California, thus indicating there should be some formations of Lower Pliocene age carrying through western Oregon.

Sediments of Miocene age are divided into two formations: The upper or Astoria formation, composed mainly of shale, and the lower or Aturia bed, also composed of shale.

Formations of Oligocene age have been worked out in considerable detail along the Oregon coast. The Nye shale is of Upper Oligocene age and may be correlated with the Blakely formation of Washington.[28] The Middle Oligocene is represented by the Eugene formation, a series of tuffs and sandstones, with basalt dikes and sills. This formation has not been correlated with any formation in either Washington or California. The Toledo formation of Lower Oligocene age is composed of tuffs, sandstones, basalt dikes and sills. This formation is correlated with the Lincoln and Porter beds of Washington.

The Wilbur Tuff Lentils are thin, tuffaceous deposits occupying a position at the top of the Upper Eocene column. Below the Wilbur Tuff Lentils is the Umpqua formation composed of 12,000 feet of thin-bedded sandstone and shale. Beneath the Umpqua is the Tyee formation. This lies at the base of the Upper Eocene column. The Middle Eocene of western Oregon is represented only by the Arago formation.

California[28]: Inasmuch as this paper is not an attempt to correlate the marine Tertiary strata of California, only a generalized section will be given for the California area.

At the top of the column is the Sagus formation of Upper Pliocene age. This may possibly correlate with the Elk River formation of Oregon. Beneath the Sagus rests the Etchegoin formation of Middle Pliocene age. This formation may be correlated with the Empire beds of Oregon and the Quillayute formation of Washington. The Purisima formation lies beneath the Etchegoin. It is considered to be Lower Pliocene in age and may correlate with the Quinaielt of Washington.

Two formations of Miocene age are recognized in this area. The upper, the Monterey, correlates with the Astoria shale of Oregon and the Montesano formation of Washington. The lower, or Temblor, correlates with the Aturia bed of Oregon and the Chehalis and Wahkiakum formations of Washington.

The San Lorenzo (Porter) a formation of Upper Oligocene age, correlates with the Nye shale of Oregon and the Blakely formation of Washington. Lying below the San Lorenzo (Porter) is the San Emigdio, a formation which corresponds with the Toledo volcanic series of Oregon and the Lincoln beds of Washington. It is of Lower Oligocene age. The San Lorenzo corresponds to the Porter formation of Washington. It may be but a member of the San Lorenzo, for immediately below beds typical of the San Lorenzo reappear.

Three formations of Upper Eocene age occur in California, the uppermost of which is known as the Marysville Buttes formation. This formation correlates with the Wilbur tuff Lentils of Oregon. The middle formation is known as the Meganos and correlates with the Umpqua of Oregon. The lowest formation is still of Upper Eocene age. It is the upper Tejon and correlates with the Tyee sandstone of Oregon. All three formations corres-

pond to the Puget Series of Washington.

The lowest recognized California Tertiary formation is the Tejon of Middle Eocene age. This formation correlates with the Arago of Oregon and the Crescent of Washington.

Summary

Correlation of the Tertiary strata in the Northwest has brought out most strikingly the important role of vulcanism and continental deposition except along the immediate Pacific Coast. The record is largely one or repeated igneous activity alternating with periods of quiesence during which there were accumulations of clastic material.

Sedimentation played a dominant role during the Eocene epoch, although the epoch was not entirely free of igneous activity. During this time lavas were extruded in the Yellowstone Park region, probably in southwest Idaho, and northern Nevada (rhyolites and diabasic basalts), in eastern Oregon (Clarno, Wagon Tire Rhyolie, and Coyote formations), and in central Washington (Teanaway Basalt, and Kachess Rhyolite). At the same time sediments were being widely deposited in southwestern Wyoming, northeastern Utah, neighboring parts of southeastern Idaho, and possibly in southwest Idaho and northern Nevada. The leading formations of this interval include the Evanston, Wasatch, Green River, Bridger, Washakie, and Uinta. Sedimentation also occurred in central Washington where it alternated with periods of vulcanism. While continental sedimentation and vulcanism were going on east of Cascades, marine sediments of great thickness were being deposited along the Pacific Coast.

Little is known about the continental Oligocene in the Northwest. That some vulcanism and sedimentation did occur in eastern Oregon and Central Idaho is evidenced by the presence of the John Day formation in Oregon and the Challis volcanics in Idaho. A dacite flow conglomerate, which may possibly be of Oligocene age, is found in an isolated area in central Washington. During this same epoch marine sedimentation continued west of the Cascade Range.

Vulcanism and sedimentation were again active throughout the Miocene epoch. Periods of volcanic activity alternated with periods of quisence and sedimentation over much of the region lying between the Cascade Range and the Rocky Mountains. Lavas were extruded in the Yellowstone Park area while in southeast and southcentral Idaho and northern Utah sedimentary strata and pyroclastics were intercalated with and capped by lavas. This gave rise to the Salt Lake formation. Relatively short periods of vulcanism alternated with periods of sedimentation over the western part of the interior producing such sedimentary formations as the Payette, Latah, and Ellensburg intercolated with and capped by the Columbia basalt series. During this epoch marine sedimentation prevailed along the Pacific Coast.

Sedimentation was somewhat less important than vulcanism during the Pliocene epoch. Extrusion of lava continued in the Yellowstone Park region while in southwestern Idaho, northern Nevada, west central Idaho, and parts of eastern Oregon sediments were accumulating and gave rise to the Humboldt, Idaho, Poison Creek, and Ironside formations. These clastics were deposited maily during the early and middle parts of the epoch. Ex-

trusions of basic lavas over much of the interior closed this final epoch of the Tertiary east of the Cascade Range. While vulcanism and continental sedimentation were taking place in the interior region marine sedimentation continued along the Pacific Coast much the same as it had throughout the earlier epochs of the Tertiary.

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(Continued on page 65)

Structure of A Portion of the Rocky Mountains of Northwestern Montana[1]

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THE Rocky Mountains of Northwestern Montana, in contrast to the Rocky Mountains farther south that are diversely arranged or occur in scattered mountain clusters, are roughly parallel and linear. They have a general N. 30° W. trend, although their eastern ranges curve outward toward the northeast and their western ranges curve outward toward the southwest. Furthermore their geology is in strong contrast to that of the ranges farther south, because their structure is simpler, and because they are composed almost entirely of sedimentary rocks; although igneous rocks do form conspicuous sills and in a few places small granitic stocks.

The sedimentary rocks are dominantly of Proterozoic (Algonkian) age, overlain in the eastern ranges by limestones and shales of Paleozoic age, which in turn, on the western flanks of the easternmost ridges, are overlain by shales and sandstones of Mesozoic age. The Algonkian rocks form an extraordinarily thick group of clastic sediments, at least 50,000 feet in thickness, known as the *Belt Series,* originally clays, sands, and marls, now metamorphosed into argillites, quartzites, and impure sideritic marbles and limestones.

The sedimentary rocks have been folded, broken by faults, and intruded by igneous rocks. Isoclinal and overturned folds are rare, but longitudinal, reverse, and overthrust faults of great length are numerous and form the most characteristic geologic feature of the region. Many of the ranges are fault blocks and many of the long wide valleys between the ranges follow faults. In general, the eastern base of the ranges fronting the Great Plains is marked by an overthrust fault dipping southwestward at a low angle under the ranges. This fault has been named the Lewis Overthrust, since it occurs along the east base of the Lewis Range of Glacier Park. The western base of most of the western ranges is marked by thrust faults that dip steeply to the northeast under the ranges.

The rocks of the western ranges dip 20° to 50° to the northeast, and are repeated by the longitudinal thrust

[1]Presented at the Annual Meeting of the Northwest Scientific Association, December 29-30, 1931, Spokane, Washington.

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A Tentative Correlation of Northwestern Tertiary Strata

(Continued from page 64)

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faults, that dip even more steeply to the northeast. The eastern or front ranges are cynclinal and as mentioned, are abruptly bounded by the Lewis Overthrust. However, east of the Lewis and Clark range south of Glacier Park, and also east of the Lewis Overthrust, a series of longitudinal thrust faults, dipping steeply to the southwest, produce a series of thin fault blocks or slices, of Paleozoic and Mesozoic rocks, eroded into extremely rugged parallel ridges. The southwesterly dipping thrust and overthrust faults are convex to the northeast and the northeasterly dipping thrust faults are convex to the southwest, both following the arcs of the ranges. But these long longitudinal faults are broken by two series of younger transverse faults; one set having a nearly east-west trend, and the other nearly a north-south trend.

The sedimentary rocks deposited during the Proterzoic, Paleozoic, and Mesozoic eras were deformed and intruded and in places covered by igneous rocks during the Rocky Mountain or Laramide Revolution. Uplift, and volcanic activity evidently began during the late Mesozoic and were virtually completed by Middle Eocene time. It appears as if the forces causing deformation acted from the southwest, first uplifting and folding the rocks, and breaking them along the steeply dipping thrust faults. The western northeasterly dipping faults were probably formed somewhat earlier than the eastern southwesterly dipping ones, but together they made a series of huge downward pointing wedges. Somewhat later the deformation continued to such an extent that relief from the stresses came by the overthrusting of the elevated, deformed, and stronger during the Proterozoic, Paleozoic, and Proterozoic and Paleozoic rocks to the east onto the much weaker Mosozoic rocks of the Great Plains region.

It is suggested that the two sets of transverse faults were a secondary effect of the elongation to the northwest and southeast which results from pressure from the southwest and consequent contraction in that direction after further uplift was impossible, because for the rocks to move horizontally was easier than to be uplifted higher.

Fifty Years of Weather in The Inland Empire[1]

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WHILE weather records have been kept at a few stations in the Inland Empire for over fifty years, most of the records extend back only ten to thirty years. Numerous records are fragmentary and have been kept for only short periods of time. It seems doubtful if records are complete enough and have been kept for sufficient time to give entirely accurate statistics regarding rainfall and other climatic elements. Climatic maps of the Inland Empire must be regarded as approximations and subject to revision in accord with later compilations of data.

The oldest records extend back as follows:

*Missoula	1871
Lewiston	1880
Walla Walla	1873
Spokane	1881

*(but records are fragmentary until 1881)

The climate of the Inland Empire is of a transition type between the rainy oceanic climate of the Pacific Coast that has moderate range of temperature and the semi-arid continental climate of the Interior of North America, that has extreme range of temperature from summer to winter.

The distribution of rainfall corresponds with the Northwest Pacific coast. Maximum precipitation occurs during the months of November to February inclusive. This is in striking contrast to eastern Montana where one-half the annual rainfall comes in May, June and July. Summer thunderstorms occur especially in the mountains of the Inland Empire, but do not furnish generally large quantities of water. In amount of annual rainfall the Inland Empire has a continental character because of the pronounced rain shadow effect of the mountains to the west. Part of the Columbia Basin with 6 inches of rainfall annually is drier on an average than any part of the northern Great Plains. This results in part from adiabatic heating of the winds descending the eastern Cascade slopes.

Inland Empire rainfall depends primarily on nearness to the Pacific Ocean, exposure to the winds blowing from the water, the frequency of cyclonic storms in autumn, winter and spring, and the relief of the land. Our prolonged droughts result from the dominance of the continental "High". This may cause "lows" to pass too far to the north or south to cause precipitation here. When "lows" follow each other closely across the Inland Empire vast masses of warm moist air invade this region and bring abundant precipitation as during December, 1931. A rainfall map clearly shows the influence of relief. Mountains have 20-40 inches of rainfall while lowlands and valleys like the Columbia, Snake, Bitterroot and Flathead have 10-12 inches or less. The Palouse region and the country west of the Blue Mountains illustrate the effect of exposure to winds from the ocean, since they benefit from masses of air that move up the Columbia Gorge with less loss of moisture than in the broader and higher Cascades to north and south.

[1]Presented at the Annual Meeting of the Northwest Scientific Association, December 29-30, 1931, Spokane, Washington.

Inland Empire temperatures result from relative latitude, prevailing winds, the passing of "lows" and "highs", altitude and exposure of stations. East of the Cascades continental extreme of temperatures occur. For instance, Spokane and Tatoosh Island both have an annual temperature of 48°F. Spokane, however, averages 69°F in July and 27°F in January, while Tatoosh Island averages, in July, 56°F and in January 41°F. The highest temperature recorded in Spokane is 107°F and the lowest—30°F, while Tatoosh Island shows 85°F and 7°F for extremes.

Ordinarily eastern Washington is protected by the barrier of the Rocky Mountains from the coldest waves that descend from the Arctic over the Great Plains. Low pressure in California that lasts several days when combined with high pressure on the Great Plains cause the cold air to spill over the mountain barrier and invade the Columbia Plateau. Conversely, a "low" to the north and a "high" in Oregon results in Chinook winds and milder weather.

The northern latitude gives Washington 16 hours of sunlight daily the last of June. This helps certain crops materially.

Controlling factors for agriculture include rainfall and length of growing season as determined by the last frost of spring and the first frost of fall. Even the soil is dominantly affected by rainfall and vegetation and a leading influence on vegetation is rainfall. A map of natural vegetation coincides closely with annual rainfall, after allowances are made for elevation. In the ultimate analysis, therefore, climate is probably the most important single factor that affects man in the Inland Empire.

The Structure of the Natapoc Formation North of Leavenworth, Washington[1]

By Everett Houghland
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NATAPOC formation is used here to designate the sandstone series located about 11 miles north of Leavenworth, Wash., and about 15 miles east of the crest of the Cascade Mts. It is Tertiary in age and unconformably overlies metamorphic rocks. Mr. Parrott has shown that this formation is about 15,000 feet thick.

The Natapoc formation has been folded into at least two anticlines and two synclines with an average dip of 40 degrees. The axes of thes folds strike a few degrees west of north. The major fold is an anticline between 7 and 8 miles wide at the base. In two places along its axis the underlying rock has been exposed by erosion. From the unmetamorphosed character of the beds and the slight shearing effects it is inferred that this series was not subjected to intensive stresses during the folding.

These facts lead mainly to two tentative conclusions: first, that the forces were operative in a general east-west direction, and second, that the folding occurred at approximately the same time as the last uplift of the Cascades.

[1]Abstract of paper presented at the Annual Meeting of the Northwest Scientific Association, December 29-30, 1931, Spokane, Washington.

A Contribution to the Latah Flora of Idaho[1]

By
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University of Idaho

During the last five or six years there has been discovered and described a very interesting and extensive fossil flora in the Latah formation in Idaho and in eastern Washington. The Latah formation is contemporaneous with and is intercalated in the Columbia lavas. It is, therefore, for the most part probably of Upper Miocene age. This flora is, therefore, of more than ordinary value, not only as an indicator of the general climatic conditions of the Pacific Northwest during the middle Tertiary time, but also as an evidence of the nature of the last well established mixed forest flora before the advent of Pleistocene time.

The Latah formation is made up of clastic materials, sands, silts, clays with varying amounts of diatomaceous earth and fine volcanic ash which were deposited in lakes and ponds formed by blocking of the established drainage by the great Columbia basalt flows. The general period of eruption consisted of some two or three shorter periods of intense activity separated by periods of quiescense during which soil formed and plants re-established themselves. Because of the intermittent nature of the volcanism, the Latah flora is not strictly of one and the same age. It probably ranges from Middle Miocene to the beginning of Pliocene time.

So far as the writer has been able to determine, the discoverers of this most interesting flora are Messrs. I. A. Bonser, C. O. Fernquist and E. E. Alexander of Spokane, Washington, who made a comprehensive collection of the materials for the Eastern Washington Historical Society of Spokane. The pioneer students of the geology of the Latah Formation were Pardee and Bryan, who also made extensive collections of the plant remains in the vicinity of Spokane and of Coeur d'-Alene, Idaho. These collections were described by Knowlton[2] and his descriptions were included in their report.

Some two or three years later V. R. D. Kirkham, who at that time was an instructor in the University of Idaho, became interested in the stratigraphic position of the Latah formation in Idaho. In connection with his stratigraphic and lithologic studies he made collections of fossil plants from a number of localities, extensively from Whitbird, Idaho, and in a smaller way from several others. These collections were studied by Berry and his descriptions were incorporated in an article which Kirkham published in the Journal of Geology.[3]

In 1928, while carrying on graduate study in paleobotany in the University of Idaho under direction of Dr. F. B. Laney, Head of the Department of Geology, the writer became convinced that the Latah flora merited more extensive study than it had received. He and Dr. Laney visited all the known localities in northern Idaho, except those near Coeur d'Alene and St. Maries, and made large collections from each of them. To the material

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[1]Presented at the annual meeting of the Northwest Scientific Association, December 29-30, 1930, Spokane, Washington.

[2]U. S. Geol. Survey, Professional Paper No. 140, 1925, pp. 1-55.

[3]Journal of Geology, vol. 37, 1929, pp.

thus obtained were added smaller collections made by Gerhard Kempff formerly of the School of Forestry of the University of Idaho, and by Earl Monnett of the Lewiston High School. This collection, by far the largest and most comprehensive thus far made, has been studied systematically from the fall of 1928 until 1932.

No startling new discoveries have been made. The results of studies have, however, rounded out the data obtained by Knowlton and Berry and have for the first time made it possible for the student to successfully see the Latah plants as a true flora which was in mid-Tertiary time apparently characteristic of that part of the northern Rocky Mountain region known as the Inland Empire. These studies have also made it possible to understand the general ecological conditions under which this unusual flora, cosmopolitan mesophytic in aspect, lived and flourished. Much light has been thrown upon the former habitat of plants which at present are found only in widely scattered and entirely disconnected places. They have also added many data to the increasing knowledge of the climate of this region during the Tertiary period. A number of new species of plants were found, described and photographed.

The work of Knowlton and Berry is so comprehensive and of such a high standard of excellence that it would be presumptuous on the part of the writer to attempt a revision or to try to devise a different form of presenting data. The tabular method used by Kirkham in stating the taxonomic-locality data supplied by Knowlton and Berry has been adopted and the table has been extended and somewhat rearranged, so as to save space in presenting the new data. The following explanations should make everything clearly understandable.

1. Spokane-Coeur d'Alene, Flora by Knowlton & Berry in U.S.G.S. Prof. Paper 140. U.S.G.S. Prof Paper 154-H.

2. Whitebird, ½ to 2 miles east of Whitebird, Idaho, and includes Kirkham's localities 8, 9, 12, 14.

3. Arrow Junction, Idaho=Kirkham's localities 16, 17, 24, 25, 26.

4. Juliaetta, Idaho=Kirkham's locality 27.

5. Lewiston, 11 miles east of Lewiston, Kirkham's localities 1, 2, 3, 4, 5.

6. St. Maries. The writer was unable to visit the St. Maries deposits.

7. Grangeville Mountain.

8. Oviat Creek, five miles west of Elk River, R. 1 E., T. 39 N., S. 1.

9. Elk River, 3 miles west of Elk River, R. 2 E., T. 40 N., S. 33.

10. Clearwater Lumber Camp 2, four miles southeast Elk River, R. 2 E., T.39 N., S. 8.

11. Payette flora.

12. Florissant flora.

Note: The x in column 1 of the table=flora recorded for Spokane-Coeur d'Alene by Berry and Knowlton. The x in columns 2, 3, 4, 5, 6=Kirkham's records. The o in any column=Ashlee-Laney records.

ALPHABETICAL LIST OF KNOWN SPECIES OF LATAH FLORA.

	1 Spokane-Coeur d'Alene	2 Whitebird	3 Arrow Junction	4 Juliaetta	5 Lewiston E	6 Saint Maries	7 Grangeville Mountain	8 Oviat Creek	9 Elk River	10 Clearwater Lumber Camp No. 2	11 Payette	12 Florissant
Acer bendirei, Lesq.	X	O				X						
Acer chaneyi, Kn.	X	O	X									
Acer florissanti, Kirchner		X		X					O		X	X
Acer merriami, Kn.	X	X	X	X	X							
Acer minor, Kn.	X	O			X							
Acer origonianum, Kn.	X	X								O		
Acer vivarium, Kn.	X	X										
Acer sp.	X	X										
Acer sp.				O								
Acer sp.												
Acer sp.												
Acer sp. samara									O			
Acer sp. (macrophyllum, Purth?)		O							O			
Aesculus hesperia, By.	X	O										
Alnus elliptica, By.	X											
Alnus prerhombifolia, By.	X											
Alnus sp.	X											
Alnus sp. Cones	X											
Alnus sp. Pistillate aments	X			O								
Amelanchier grayi, Chaney	X				X							
Amelanchier scudderi, Cockerell	X											
Amelanchier sp.				O			O					
Apocynophyllum latahense, By.	X			O								
Aralia whitneyi, Lesq.	X											
Archaeomnium patens, E. G. Britton	X											
Arisaema hesperia, Kn.	X											
Artostaphylos knowltoni, By.	X											
Arctostaphylos spatulata, By.	X											
Asplenium occidentale, By.	X											
Betula bryani, Kn.	X	O					O					
Betula fairii, Kn.	X	O	X	O								
Betula heteromorpha, Kn.	X	X		O		X		O				
Betula ? largei, Kn.	X			O	X	X						
Betula thor, Kn.	X	O	X									
Betula, Winged fruit	X											
Betula sp.				O								
Carpinus sp.	X											
Carpites boraginoides, Kn.	X			X								
Carpites ginkgoides, Kn.	X											
Carpites menthoides, Kn.	X	X										
Carpites paulownia, Kn.	X											
Carpites polygonoides, Kn.	X											
Carpites spokanensis, Kn.	X											
Carpolithus sp.	X				X							
Carpolithus pteraformis, By.	X											
Castanea castaneafolia (Unger) Kn.	X	X			X	X		O	O	O	X	
Castanea orientalis, Chaney.	X	O							O			
Castanea pulchella, Kn.		O						O	O		X	
Cassia idahoensis, Kn.	X	X										
Cassia sophoroides, (Kn.) By.	X	X		X				O	O	O		
Cassia spokanensis, By.	X	O						O				
Celastrus confluens, Kn.		O										
Celastrus fernquisti, Kn.	X	O										
Celastrus lacosi, Lesq.	X										X	
Ceratophyllum sp.		O										
Cercidium sp. Fruit									O			

	1	2	3	4	5	6	7	8	9	10	11	12
Cercocarpus praeledifolius, By.	X											
Ceris idahoensis, By.		X							O	O		
Cercis ? spokanensis, Kn.	X											
Cercis, sp.		O		O				O	O			
Comptonia hesperia, By.	X									O		
Comptonia insignis (Lesq.) Cockerell	X							O		O		X
Cornus acuminata, By.	X											
Cornus sp.									O			
Corylus ? sp.										O		
Crataegus sp.		O		O								
Diospyros andersonae, Kn.	X											
Diospyros princetoniana, Cockerell	X											
Diospyros sp.				O								
Diospyros sp.								O				
Equisetum, Underground stem	X	X										
Equisentum, Underground stem tubercles									O			
Euonymus knowltoni, By.	X	X										
Fagopsis longifolia, (Lesq.) Hollick	X	O										
Fagus pacifica, Chaney	X	X		O				O	O	O		
Fagus sp.									O	O		
Fagus ? sp. Seed									O			
Ficus ? washingtonensis, Kn.	X	O		O			O		O	O		
Fraxinus ? Fruits	X	X										
Ginkgo adiantoides, (Unger) Heer.	X	O		O								
Glyptostrobus sp.				O								
Glyptostrobus europaeus, (Brongniart) Heer.	X	X			X							X
Hibiscus occidentalis, By.	X			X								
Hydrangea bendirei, (Ward) Kn.	X									O		
Hydrangea sp.										O		
Ilex sp.				O					O			
Juglans affinis, Kirchner	X	O										
Juglans sp.		O		O								
Juncus ? crassulus, Cockerell	X											
Kalmia ? sp.									O			
Lauris grandis, Lesq.	X	X				X		O	O	O		
Laurus princeps, Heer.	X	X		X					O	O		
Laurus similis, Kn.	X	X		X	X		O	O	O	O		
Leguminosites alexanderi, By.	X											
Leguminosites bonseri, By.	X											
Liquidambar californica, Lesq.	X	X	X				O	O	O	O		
Liquidambar, Fruits	X	X		X					O	O	X	
Liriodendron hesperia, By.	X	O										
Lycopodium hesperium, Kn.	X	X										
Magnolia californica, Lesq.	X											
Magnolia dayana, Cockerell	X	X		X				O		O		
Magnolia sp. Fig. 1, Pl. XXVII, P. P. 140	X	O										
Magnolia sp.	X		X				O		O			
Malva ? hesperia, Kn.	X											
Meibonites knowltoni, By.	X											
Meibonites lucens, Kr.	X	X								O		
Menziesia knowltoni, By.	X	O										
Menispermites latahensis, By.	X											
Myrica lenceolata, Kn.	X	O	X								X	X
Myrica sp.									O	O		
Myrica sp.									O			
Nyssa knowltoni, By.	X	X								O		
Nyssa magnifica, (Kn.) By.	X											
Nyssa, small fruits	X	X										
Nyssa, fruit									O			
Ostrya oregoniana, Chaney?	X	X										
Palaeopotamogeton florissanti, Kn.	X											X
Paliurus hesperia, By.	X											
Paliurus knowltoni, By.	X				X							
Phyllites amplexicaulis, Kn.	X											
Phyllites crustacea, Kn.	X											
Phyllites pardeei, Kn.	X											

	1	2	3	4	5	6	7	8	9	10	11	12
Phyllites peculiaris, Kn.	X											
Phyllites relatus, Kn.	X											
Phyllites sp.	X											
Pinus latahensis, By.	X											
Pinus macrophylla, By.	X											
Pinus monticolensis, By.	X									O		
Pinus tetrafolia, By.	X											
Pinus, Staminate aments.	X											
Pinus sp.	X	O										
Pinus sp. Cone										O		
Pinus sp. 3-needled									O			
Platanus aceroides latifolia, Kn.		O										
Platanus aspera, Newberry	X										X	
Platanus appendiculata, Lesq. ?	X											
Platanus dissecta, Lesq.	X	X				X			O	O	X	
Platanus sp. Fruit										O		
Polystichum sp.		O										
Polytichites washingtonensis, E. G. B.	X											
Populus eotremerloides, Kn.	X										X	
Populus fairii, Kn.	X	O	X									
Populus heteromorpha, Kn.	X	X	X	X	X		O	O	O	O		
Populus lindgreni, Kn.	X	X	X	X						O	X	
Populus washingtonensis, Kn.	X	O										
Populus sp.	X	X										
Populus sp.					X				O			
Populus sp. Pistillate aments.	X											
Porana microcalyx, (Kn.) By.	X	X		O								
Polytrichites spokanensis, E. G. B.	X											
Potamogeton heterophylloides, By.	X				X						X	
Potamogeton sp.	X	O										
Potamogeton sp.									O			
Prunus rustii, Kn.	X				X							
Pteris sp.	X				X						X	
Quercus bonseri, Kn.	X											
Quercus cognatus, Kn.	X	X		X			O		O	O	X	
Quercus consimilis, Newberry	X											
Quercus dayana, Chaney	X											
Quercus duriuscula, Kn.	X											
Quercus horniana, Lesq.												
Quercus idahoensis, Kn.	X				X						X	
Quercus merriami, Kn.	X									O		
Quercus obtusa, Kn.	X											
Quercus payettensis, Kn.	X	O		X	X			O	O	O	X	
Quercus cf. Quercus pseudolyrata, Lesq.	X								O	O		
Quercus rustii, Kn.	X	O					O	O		O		
Quercus simplex, Kn.	X											
Quercus simulata, Kn.	X	X		X	X			O	O	O	X	
Quercus spokanensis, Kn.	X							O	O	O		
Quercus treleasii, By.	X	X						O		O		
Quercus ursina, Kn.	X											
Quercus No. 8, Pl. 52, P.P. 154, H. Berry.	X								O			
Quercus, acorn	X	O						O				
Quercus, cup	X	O										
Quercus sp.		O										
Quercus sp.		O		O								
Quercus sp.				O					O			
Rhus merrilli, Chaney	X	X		X								
Rhus Payettensis												
Rhus typhinoides, Lesq.	X											
Ribes fernquisti, By.	X	O							O			
Robinia ? sp.		O								O		
Rubus sp.							O					
Rhamus spokanensis, By.	X											
Salix florissanti, Kn. & Cockerell	X				X							
Salix inquirenda, Kn.	X	X		X								

	1	2	3	4	5	6	7	8	9	10	11	12
Salix perplexa, Kn.	X											X
Salix remotidens, Kn.	X											
Salix sp.	X											
Salix sp.				O								
Salix, Pistillate flower	X											
Sapindus armstrongi, By.	X							O				
Sapindus spokanensis, By.	X											
Sassafras hesperia, By.	X	O							O			
Sequoia couttsiae, Heer.										O		
Sequoia lanksdorfii, (Brongt.) Heer.	X	X	X	X	X				O	O	X	
Sequoia langsdorfii, Pistillate cone		O										
Sequoia sp., Staminate cone		O										
Sequoia ? sp.		X										
Sequoia sp. Cone		O									X	
Smilax lamarensis, Kn.	X	X										
Smilax sp.										O		
Sophora alexanderi, Kn.	X	X							O			
Sophora spokanensis, Kn.	X	X		X			O	O		O		
Sopora sp.		O										
Taxodium dubium, (Stnbg.) Heer.	X	X	X	X		X	O	O		O		
Taxodium Staminate aments.	X	X		O			O	O	O	O		
Taxodium, Cone		O										
Taxodium, Seed	X	X										
Taxodium sp.												
Ternstroemites idahoensis, (Kn.) By.	X			X								
Tilia hesperia, By.	X	O										
Tsuga latahensis, By.	X	O										
Tumium bonseri, Kn.	X											
Typha lasquercuxii, Cockerell	X											X
Typha sp.	X			O					O			
Ulmus bdownelli, Lesq.	X			X								
Ulmus fernquisti, Kn.	X								O			
Ulmus speciosa, Newberry	X	O	X							O	X	
Ulmus, Fruit	X	O										
Umbelliferospernum latahense, By.	X											
Umbellularia dayana, (Kn.) By.	X	O	X						O			
Umbellularia lanceolata, By.	X	X		O			O		O			
Umbellularia oregonensis, Chaney				O								
Vaccinium americanum, (Lesq.) By.	X											
Vaccinium bonseri, By.	X											
Vaccinium bonseri serrulatum, By.	X											
Vaccinium spokanense, By.	X											
Viburnum fernquisti, By.	X											
Viburnum lantanafolium, By.	X											
Viburnum sp.		O										

A glance at the table shows clearly that the fossil plants of Idaho localities are so similar as to be safely considered of the same age and of ecological identity, with the exception of those from the Payette formation. This flora, however, is distinctly related to the Latah. The smaller number of records for St. Maries is due to the fact that we were unable to visit this district. The species recoded by Kirkham are a typical Latah collection and were published by him as a list of index species.[4]

The fossiliferous beds near Whitebird were first made known to the Department of Geology, University of Idaho, through their discovery by workmen engaged in highway construction. The beds are of light-colored sedimentary rocks composed of sand, silt, clay, volcanic ash, and diatomaceous earth. They were once covered by basalt, which has been re-

[4]Journal of Geology, vol. 38, 1930, p. 663.

moved by erosion. The formation consists of some seven non-fossiliferous strata, composed of sand, volcanic ash and small amounts of silt and clay, about eight inches thick, which occur in the fossil-bearing horizons at regular intervals of about eight feet. There is no change in the character of the fossils above or below these layers. The lowest part of the beds examined is a little above the water surface of Whitebird Creek, where the material is lignite and the fossils much inferior to those in the upper part of the area. The best fossils found in the lignite were Liquidambar fruits.

In the column giving the Spokane-Coeur d'Alene flora it will be noticed that 178 species are recorded, 24 in excess of the number recorded by Berry.[5] This apparent discrepancy is caused by the inclusion of 24 species from this locality which were mentioned by Kirkham in his paper on the Latah Formation.[6] Of these 176 species, 77 or 43.7 per cent are also found at Whitebird. The total record for Whitebird is 97 species, 76.85 per cent of which are common to the type Latah localities.

At Arrow Junction and the Lewiston locality Kirkham made only a sufficient collection to establish the age of the fossil beds. It will be noticed that *Populus heteromorpha,* Kn., *Acer merriami,* Kn., *Taxodium dubium* (Stenbg.) Heer., and *Sequoia langsdorfii* (Wrongt.) Heen., are common to both and to Spokane-Coeur d'Alene. The fossils recorded from St. Maries are equally typical of the Latah flora. They are *Acer benderi,* Lesq., *Betula heteromorpha,* Kn., *Betula largei,* Kn., *Laurus grandis,* Lesq., *Platanus dissecta,* Lesq., *Populus heteromorpha,* Kn., *Castanea castaneafolia* (Unger), Kn., and *Taxodium dubium* (Stenbg.) Heer.

There are 46 species recorded from Juliaetta, 33 being common to the Latah of Spokane-Coeur d'Alene. We record 14 from Grangeville Mountain, of which 13 are common to Spokane-Coeur d'Alene and 10 are common to Whitebird. *Betula bryani,* Kn., *Laurus similis,* Kn., *Liquidambar californica,* Lesq., Magnolia sp., *Populus heteromorpha,* Kn., *Quercus cognatus,* Kn., and *Sophora spokanensis,* Kn. are common fossils in this locality. The *Taxodium dubium* is fairly common, but Sequoia appears to be absent. The fossiliferous beds at Elk River (column 9) were exposed through quarrying operations. The rock is of the same general character as at Whitebird and the other localities from which collections were made. The beds are divided by a basaltic flow about eight feet thick, but there is no change in general character of the fossils above or below the basalt. We record 48 species from this locality, 29 being common to Spokane-Coeur d'Alene. The beds at Oviat Creek were brought to light through logging construction and through stream erosion. So far we have recorded 24 species from this locality, 21 being common to Spokane-Coeur d'Alene flora. The Clearwater Lumber Camp No. 2 locality was also exposed through the building of a logging railway. We record 44 species from here, 33 of which are common to Spokane-Coeur d'Alene.

The fossiliferous beds at Oviat Creek, Elk River and Clearwater Lumber Camp No. 2 are separated by only a few miles. It is of interest to take the total records for all three and compare them with Spokane-Coeur d'Alene. The total number is 75, of which 48 or 64 per cent are common to the Latah of Spokane-

[5]U. S. Geol. Survey, Professional Paper No. 154, 1930.
[6]Op. cit.

Coeur d'Alene. *Populus heteromorpha,* Kn. is approximately the best index fossil, since it appears to be the only one common to all localities.

Probably the most interesting feature of the fossil flora of the Latah formation is the association of species belonging to genera that are now isolated. These fossil plants link geographically distant places and help us to realize the effect of geologic change on the distribution of plants.

The following table, compiled from Bailey,[7] Sargent,[8] Raeder,[9] and Hutchingson,[10] presents the essential facts concerning the present geographic distribution of the genera of ligneous plants that have been identified in the Latah formation:

Genus	*Number of Species*	*Present Geographical Distribution*
Acer	150	Temperate regions of Northern Hemisphere.
Aesculus	25	E. and W. North America, Europe and terperate Asia.
Alnus	15	Northern Hemisphere south to Central America.
Amelanchier	25	E. and W. North America, Europe and temperate Asia.
Aralia	20	North America, Malaya, Asia and Australia.
Arctostaphylos	50	North and Central America (1 circumpolar).
Betula	4	Temperate regions of Northern Hemisphere.
Carpinus	20	Northern Hemisphere, south to Central America.
Cassia	380	Warmer regions of both hemispheres, except Europe, Tasmania and New Zealand.
Castanea	8	Temperate regions of Northern Hemisphere.
Celastrus	30	E. and W. Asia, Australia, Madagascar, E. North America.
Cercidium	4 or 5	Southern borders of U. S. A., Mexico to Central America.
Cercis	7	E. and W. North America, Europe and temperate Asia.
Cercocarpus	20	Oregon to Mexico.
Comptonia	1	Nova Scotia to South Carolina.
Cornus	40	E. and W. North America, Europe and temperate Asia.
Corylus	15	E. and W. North America, Europe and temperate Asia.
Crataegus	1000	(Principally developed in Eastern U.S.A.)
Diospyros	200	Principally tropical and sub-tropical regions.
Euonymus (Evonymus)	120	North and South America, Asia and Australia.
Fagus	9	Temperate regions of Northern Hemisphere.
Ficus	600	Tropical and sub-tropical regions of both hemispheres.
Fraxinus	65	Northern Hemisphere, in America south to Mexico, Asia south to Java.
Ginkgo	1	Confined to China.
Glyptostrobus	1	Confined to China.
Hibiscus	200	Tropical and sub-tropical and temperate regions of both hemispheres.
Hydrangea	35	North and South America, Europe, North Africa, Asia south to Java.
Ilex	300	Largest number in Brazil and Guiana, 13 E. North America.
Juglans	15	Northern Hemisphere south to Central America.
Kalmia	8	North America and West Indies.
Laurus	2	Mediterranean region, Canary Isles and Madeira.
Liquidambar	4	E. North America, Central America, W. and E. Asia.
Liriodendron	2	1 Eastern North America, 1 China.
Magnolia	35	E. North America, Central America, E. Asia and Himalaya.
Menziesia	7	E. and W. North America and E. Asia.
Myrica	35	Sub-tropical and temperate regions of both hemispheres.
Nyssa	6	4 E. North America, 2 E. Asia.
Ostrya	7	North and Central America, Europe, W. and E. Asia.
Paliurus	6	South Europe and East Asia.
Pinus	80	Northern Hemisphere from Arctic to Guatemala, W. Indies, North Africa, Malay Archipelago.

[7] Bailey, L. H., Manual of Cultivated Plants.
[8] Sargent, John H., Trees of North America.
[9] Raeder, Alfred, Manual of Cultivated Plants and Shrubs.
[10] Hutchingson, J., Claassification of Flowering Plants.

Genus	*Number of Species*	*Present Geographical Distribution*
Platanus	6 or 7	Temperate regions of Northern Hemisphere.
Populus	30	From Arctic south to high mountains in Tropics.
Porona	15	Old World Tropics and North Australia.
Prunus	200	Northern Hemisphere, south to South America.
Quercus	200	Temperate regions of Northern Hemisphere, in Tropics at high altitudes, south to Colombia in America and Malay Archipelago in Asia.
Rhamnus	100	Northern Hemisphere south to South America.
Rhus	150	Sub-tropical and temperate regions of both hemispheres.
Ribes	150	Northern Hemisphere south to South America.
Robinia	20	North America and Mexico.
Rubus	400	Chiefly colder regions of Northern Hemisphere, a few in Tropics and Southern Hemisphere.
Salix	300	Chiefly colder regions of Northern Hemisphere, few in Southern Hemisphere, none in Australia.
Sapindus	15	Chiefly in Tropics, 3 in U. S. A.
Sassafras	3	1 E. North America, 1 in China, 1 in Formosa.
Sequoia	2	From southern Oregon to California.
Smilax	200	Tropical, sub-tropical and temperate regions of both hemispheres.
Sophora	20	Temperate Asia and North America.
Taxodium	2	S.E. U. S. A. and North Mexico.
Tilia	30	Temperate regions of Northern Hemisphere, E. North America south to Mexico, in Asia south to central China and Southern Japan, none in W. north America.
Tsuga	10	Temperate Asia and North America.
Tumium (Torrya)	6	E. and W. North America and E. Asia.
Ulmus	18	Temperate Northern Hemisphere, none west of Rocky Mountains.
Umbellularia	1	South Oregon to California.
Vaccinium	130	From Arctic south to high mountains in Tropics.
Viburnum	120	North and Central America, Europe, North Africa, Asia south to Java.

The genera, Sequoia, Taxodium, Liquidambar, Glyptostrobus, Ginkgo and Magnolia are not at present components of any single ecological group. Species of Liquidambar and Magnolia have been found in the living flora of southeastern Asia. In both habitats Magnolias are the more abundant and more widely distributed of the two. Ginkgo and Glyptostrobus are now confined to southwest China and are so greatly reduced that each genus consists of a single species.

The genus Laurus today consists of a single species and is found only in the Mediterranean region, Canary Islands and Madeira. Recent and instructive data concerning distribution of Laurus in Tertiary time is given by Morita[11] in a description of a Neogene flora of Uzen Province of Japan. He describes four species which are common in the Latah flora, viz., *Laurus princeps, Laurus californica, Glyptostrobus ? europaeus* and *Taxodium dubium.* More remarkable, however, is the occurrence as a fossil in the Uzen flora of the existing *Laurus nobilis* of the Mediterranean region. Of other genera common in the Latah flora Morita mentions Salix, Sophora, Ulmus, Diospyros, Betula, Quercus, Castanea, Fraxinus, Pinus, Magnolia and Ficus. Morita's work apparently makes it certain that the broad-leaved lauraceous plants of the Latah belong to the genus Laurus.

The probable climatic conditions under which the Latah flora flourished arouses perhaps the greatest general interest. Berry, Chaney and Knowlton[12] are not in agreement upon the subject. Because of this, it seems de-

[11]Morita, H., Japanese Journal of Geology and Geography, vol. 9, 1931, pp. 1-8.

[12]Op. cit.

sirable to present a brief discussion of the subject.

The commonest trees in the Latah flora are poplars, oaks, sequoias, maples, bald cypress, chestnuts and birches. The flora was therefore decidedly mesophytic in espect. In eastern United States the greatest variety of deciduous trees is found between thirty and forty degrees latitude. In this region, excepting mountainous districts, the number of days free from killing frosts[13] varies from 180 to 240. The forest reaches its maximum development on the lower slopes of the Southern Appalachians in North Carolina and Tennessee, and in the valleys of the Ohio and lower Mississippi. The greatest part of this area falls between 34 degrees and 37 degrees latitude, the rainfall varies between 50 and 70 inches a year, July and August being the wettest months. The average temperature of the growing season is between 64 degrees and 67 degrees Fahrenheit. The dominant trees are oaks, maples, birches, ash, lime, chestnut and beech. South of the Carolinas and Tennessee the forests have a warmer climatic aspect due to the presence of evergreen oaks, perseas and magnolias. The range of evergreen trees anywhere in the temperate regions is determined more by annual and diurnal range of temperature than by relatively high mean temperature.

A rainfall of 50 inches is not necessary for the luxuriant growth of tulip trees, magnolias, oaks and maples, or indeed any of the important forest types of the eastern or southeastern states. What is necessary is an evenly distributed rainfall and absence of extreme temperatures. Representative species of oaks, sycamore, red-bud, sophora and *Ginkgo biloba* have flourished in the Royal Botanic Gardens, Kew, England, since 1760. This is a cool oceanic climate and the rainfall is less than 35 inches. It therefore appears probable that the forests of the Latah formation flourished in a climate characterized by fogs, mild winters, cool summers and a well distributed rainfall, the mean temperature of which was probably no higher than that of the southern Appalachian, or at most that of the lower Mississippi Valley at present.

Some 18 specimens were found with sufficiently distinct characteristics to warrant descriptions as new species. The descriptions follow. In establishing new species the usual paleobotanical practice was carefully followed.

Pinaceae.

No. 97, U. of Idaho collection from Whitebird, Idaho. *Juniperus sabinoides,* Ashlee.

Pl. 1, No. 1. Specimens showing three years' growth. One-year old wood bearing small (2 mm. long) acute lanceo'ate, two year-old wood bearing appressed, nearly opposite leaves somewhat spreading spirally alternate leaves, 1 mm. long, apiculate and strongly keeled. The leaves on three-year old wood appear to have been dead, but persistent, and forming a scaburous twig.

Ceratophyllaceae.

No. 85, U. of Idaho collection, from Whitebird, Idaho. *Ceratophyllum praedemersum,* Ashlee.

Pl. 1, No. 2. Fossils detached whorls of leaves; four specimines. Leaves in whorls of about 12; finely dissected, sessile, several times forked and terminating in rigid teeth. Length of leaves from 1.3 to 2 cm.

Aristolochiaceae.

No. 206, U. of Idaho collection, from Whitebird, Idaho. *Aristolochia whitebirdensis,* Ashlee.

Pl. 1, No. 3. Leaf evidently of thin, leathery texture, apical portion missing, unequally cordate at base, entire; midrib strong only near the base, soon becoming thin; secondaries exceedingly paint except the lower portion of lower pair, which arise at about 90° but are abruptly arcuate, tertiaries

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[13]Shantz, H. L. and Zon, Raphael, Atlas of American Agriculture, Sec. E, Natural Vegetation. 1924.

Read, W. G., Atlas of American Agriculture, Sec. I, Frost and Growing Season. 1924.

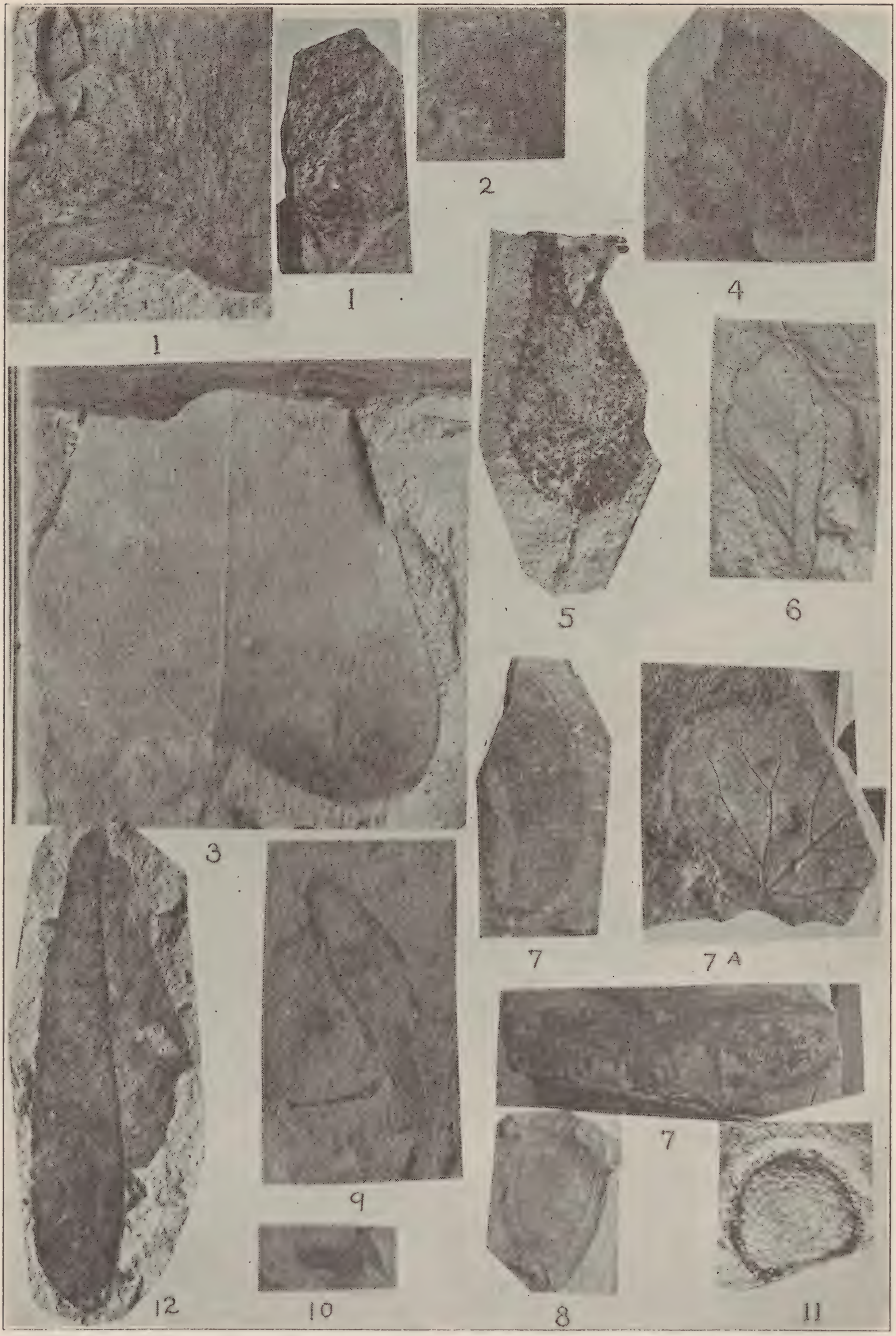

PLATE I—1. Juniperus sabinoides, Ashlee. 2. Ceratophyllum praedemersum, Ashlee. 3. Aristolochia whitebirdensis, Ashlee. 4. Rubus idahoensis, Ashlee. 5. Rubus sp. 6. Crataegus latahensis, Ashlee. 7-7. Cercis sp. 7A. Leaf associated with Cercis sp. 8. Gleditschia praeaquatica, Ashlee. 9. Cercidium hesperium, Ashlee. 10. Robinia ? idahoensis, Ashlee. 11. Platanus sp. Fruit. 12. Salix kempffii, Ashlee.

anastomosing to form a fine reticulation. Rosaceae.

No. 388, U. of Idaho collecti n from Grangeville Mountain, *Rubus idahoensis,* Ashlee.

Pl. 1, No. 4. Fossil imperfect, base missing. Leaf ovate-lanceolate, acute 4 cm. x 5.9 cm., margin doubly serrate, part of ap x missing. Midvein strong, tapering, secondaries opposite, regularly spaced, arising at an initial angle of about 45 degrees and entering the larger teeth, tertiaries entering secondary teeth or joining another secondary vein, finally nervulose and reticulated. This appears to be a terminal leaflet of a 3 or 5-foliate leaf.

No. 387. Rubus sp.

Pl. 1, No. 5. This specimen is from the same piece of rock as number 388 and is probably the same species. The specimen apparently a leaf of a fruiting branch, showing base, petiole and part of two lobes. Base rounded, margin doubly serrate but less coarse than No. 388, petiole 1.5 x 1 mm. Blade 1 cm. above, petiole 2.3 cm. wide, greatest length of specimen 5 cm., apparent length about 7 cm., the leaf apparently trilobate.

No. 53, U. of Idaho collection, from Whitebird, Idaho.

No. 414. U. of Idaho collection from Juliaetta, Idaho. *Crataegus latahensis,* Ashlee.

Pl. 1, No. 6. Leaves obovate, cuneate at base, slightly acute, lenth of No. 53, 3.8 x 2.4 mm. at widest part, No. 414, imperfect, apparent length 4 cm., greatest width 2.5 cm. Margin denticulate and slightly lobed for upper two-thirds of the margin. Madrib tapering from the base, secondaries arising to acute angles, widely spaced, alternate and entering the teeth at the lobes; tertiaries few, entering teeth; finer nervation obscure.

Caesalpiniaceae.

No. 352, U. of Idaho collection, from Oviat Creek, Idaho.

No. 460, U. of Idaho collection, from Elk River, Idaho. *Cercis* sp. Fruit.

Pl. 1, No. 7-7. *Oviat Creek specimen.* Fruit 6 cm. x 2 cm., evidently somewhat inflated, thickend on dorsal margin, round at both ends. *Elk River specimen.* Incomplete, falcate, 5 cm. x 1.5 cm. showing part of thickened dorsal margin.

These fruits were in both cases associated with leaves apparently identical with *Populus lindgreni,* Kn. The leaves appear to have a somewhat firmer texture than *P. lindgreni,* but have the same range structural characteristics. These may only be small specimens of *Cercis idahoensis,* Bry.

No. 461, U. of Idaho collection, from Elk River, Idaho. *Gleditschia praeaquatica,* Ashlee.

Pl. 1, No. 8. This fossil fruit is so close to, as to seem identical with, *Gleditsia acquatica,* Marsh, that I propose the specific name *proaeaquatica.* Description: Fruit obliquely ovate, 2.8 x 1.6 cm., stalk absene, tip 2 mm., margins thickened.

No. 527, U. of Idaho collection, from Clearwater Lumber Camp No. 2, Elk River district, Idaho. *Cercidium hesperium,* Ashle.

Pl. 1, No. 9. Fossil a legume 5.5 cm. long, acute at both ends, 1 cm. wide at widest part, clavate, slightly falcate, and evidently turgid; margins thickened; apex with sharp apical point, basal end with point 4 mm. long terminating in a persistent calyx ring.

Papilionaceae.

No. 378, U. of Idaho collection, from Grangeville Mountain, Idaho. *Robinia ? idahoensis,* Ashlee.

Pl. 1, No. 10. Pod elliptical, 1.5 cm. long, 5 mm. wide, slightly constricted near the middle, stalk 2 mm. long, apical point 1.5 mm.; three-seeded and bristly hispid.

Platanaceae.

No. 472, U. of Idaho collection, from Elk River district, Clearwater Lumber Camp No. 2. Platanus sp.

Pl. 1, No. 11. Fruit 2.7 cm. in diameter, specimen evidently a crushed globular syncarp, the margin consisting of angular nutlets, the center showing the stem scar. This fossil was found associated with *Platanus dissecta,* Lesq., and is doubtless the fruit of that species.

Salicaceae.

No. 488, U. of Idaho collection, from Elk River district, Idaho, Clearwater Camp No. 2. *Salix kempffii,* Ashlee.

Pl. 1, No. 12. Leaf thick, apparently soft, lanceolate, 9 cm. x 3 cm. at greatest width, blunt at apex, apparently rounded at base (base in specimen imperfect), margin irregularly denticulate; midrib very thick be-

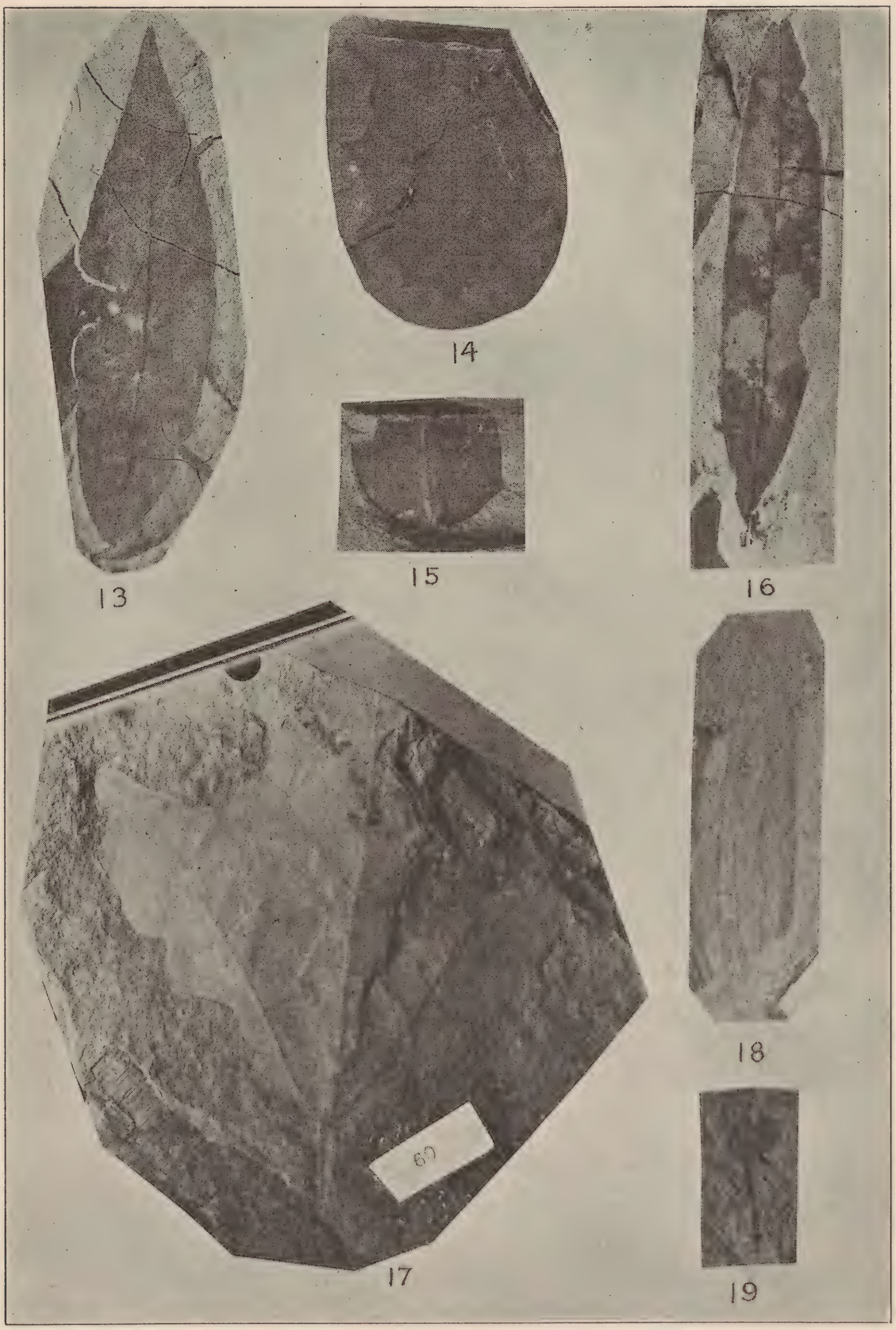

PLATE 11—13. Myrica idahoensis, Ashlee. 14. Ilex latahensis, Ashlee. 15. Ilex sp. 16. Kalmia ? elongata, Ashlee. 17. Viburnum whitebirdensis, Ashlee. 18. Smilax praelaurifolia, Ashlee. 19. Unnamed fruit.

low becoming gradually thinner towards apex, secondaries of about 16 closely spaced pairs which arise at an initial of about 45°, but soon become camptodrome and joining the next above, finer nervation not clear.

Named in honor of Professor Gerhard Kempff of the School of Forestry, U. of Idaho.

Myricaceae.

No. 301, U. of Idaho collection, from Elk River, Idaho. *Myrica idahoensis,* Ashlee.

Pl. 2, No. 13. Leaf lanceolate-elliptic, 9.3 cm. long, 2.5 at greatest width, rounded at base, somewhat acuminate at apex, finely and rather remotely serrate above the middle, lower half of margin entire, petiole missing; midrib slender, secondaries very fine, entering the teeth of the upper part of the blade, on lower half anastomosing to form a fine reticulation.

Aquilifoliaceae.

No. 463, Univ. of Idaho collection, from Elk River, Idaho. *Ilex latahensis,* Ashlee.

Pl. 2, No. 14. Leaves coriaceous elliptic-oblong or elliptic-lanceolate, truncate at base, apical portion missing, specimen 5 cm. long, apparent length 7 or 8 cm., width between basal sinuses 2 cm., between second and third 3.5 cm., margins thickened, undulate, with few very stout teeth, (specimens three on either side and part of fourth), spreading at right angles to the midrib, except lower pair which point 45° downward. Midrib stout, grooved and tapering from the base; scondaries sub-opposite, close, arising at an initial angle of 45°, ascending for about half their length, then slightly curving downward, forking near the margin. Petiole short, stout, 4 mm. long, 3 mm. wide, evidently grooved. This leaf resembles *Ilex aquilifolium,* L.

No. 399, U. of I. collection, from Juliaetta, Idaho. Ilex sp.

Pl. 2, No. 15. This specimen is inadequate for full description. This fossil is the lower part of the leaf. Length 1.7 cm., apparent total length 3 cr 3.5 cm., width 2.5 cm., base slightly cordate, margin very slightly thickened, undulate with one small tooth, midrib stout and tapering, secondaries opposite or sub-opposite, arising at an initial angle of about 60°, forked and forming a mesh near the margin. Petiole bent and only base clearly shown. This fossil is very like a leaf of *Ilex opaca,* Ait., but may be only a variant of *Ilex latahensis.*

Ericaceae.

No. 303, U. of Idaho collection, from Elk River, Idaho. *Kalmia ? elongata,* Ashlee.

Pl. 2, No. 16. Specimens, two leaves. Leaves sub-coreaceous, entire, narrowly elliptical, .9 x 1.7 cm., obtuse, margins apparently slightly undulate, petiole short 2-4 mm. long. Midrib stout, grooved, tapering from base; secondaries weak, arising at various angles, ascending for various distances; tertiaries irregularly anastomosing and forming a fine reticulation.

Caprifoliaceae.

No. 60, U. of Idaho collection, from Whitebird, Idaho. *Viburnum whitebirdensis,* Ashlee.

Pl. 2, No. 17. Leaf trilobate, lobes divergent (apical portion of central lobe missing), 7.5 cm. long, 8 cm. broad, irregularly dentate; strongly three-ribbed, secondaries rather widely spaced, arising at a wide angle and barely entering teeth, finer nervation obscure, base rounded and entire for a short distance; petiole strong, 1.5 cm. x 2 mm. This species is so near as to seem identical with *Viburnum opulus,* L.

Liliaceae.

No. 500, U. of Idaho collection, from Elk River district, Clearwater Camp No. 2. *Smilax praelaurifolia,* Ashlee.

Pl. 2, No. 18. Leaf of firm texture, oblong-lanceolate, blunt at apex, narrowed at the base (base incomplete), entire, three-nerved, 6.5 cm. x 1.5 cm., petiole missing. This species is very near *Smilax laurifolia,* L.

Unclassified.

Pl. 2, No. 19. Unnamed fruit.

The Grand Coulee[1]

By
J. HARLEN BRETZ,
University of Chicago

IT is not generally appreciated that the "Dry Falls" of Grand Coulee constitute but a small part of a much larger ancient cataract. Recent mapping by the U. S. Geological Survey shows clearly that the greater cataract had five distinct member falls. Castle Lake, one mile directly south of Coulee City, is one of these and the entire group has a width of three and one-eighth miles, much greater than that of any existing fall.

Still less has it been appreciated that Upper Grand Coulee contains the record of another cataract essentially contemporaneous with Dry Falls and its associate falls but far surpassing the magnitude of that compound feature. This Upper Grand Coulee cataract began about four miles north of Coulee City and retreated in much the fashion that Niagara is now retreating, until it cut completely through Waterville Plateau to the Columbia Valley, and so destroyed itself, leaving the canyon of Upper Coulee, but no great cataract ledge such as Dry Falls and its associates possess. This vanished cataract possessed more than a dozen smaller lateral falls during its 30 miles of recession, the laterals much like the American Falls at Niagara. These laterals, abandoned because of the greater retreat of the main falls, now hang on the margins of Upper Coulee. Northrup Canyon, Barker Canyon, Hubbard Creek and Martin Falls are some of these.

The Upper Coulee floor is a series of shallow basins today. No wells here find bed rock, showing that the shallow basins lie in a great elongated plunge pool of the vanished cataract, eroded 200 feet below the present floor.

The width of a gorge cut by a receding water-fall is determined by the width of the fall itself. Upper Grand Coulee is one and one-half to two miles wide in its southernmost eleven miles of length. North of that it widens to a maximum of five miles in the general vicinity of Steamboat Rock, and farther north it narrows again to about two miles where it notches the wall of Columbia Valley. The wide place is explicable only in terms of a great increase in discharge over the now vanished cataract ledge. This wide part of Upper Coulee, which is about ten miles long, records the Spokane flood. The flood was preceded, and followed, by a normal glacial Columbia. During the flood the vanished cataract (Steamboat Falls) was five miles wide and nearly 900 feet high. It eroded a plunge pool more than 200 feet deep and had lateral falls larger than Niagara or Victoria today.

Lower Grand Coulee lies almost wholly in the zone of tilted basalt called the "Coulee Monocline" and is wholly glacial in origin. In the vicin-

[1]Abstract presented at the Annual Meeting of the Northwest Scientific Association, December 29-30, 1931, Spokane, Washington.

ity of Lake Lenore, the pre-glacial Lower Coulee course lies about a mile to the east, parallel to the lake but 200 to 400 feet higher. It was occupied by the glacial Columbia while the first eleven miles of the Upper Coulee was being developed by cataract recession. But with the arrival of the Spokane flood, this pre-glacial route was so over-flooded that the torrent attacked the flexed and broken basalt in the monocline on the west, which had previously lain high enough to escape. Greater weakness here permitted erosion and the deepest place in the great torrent channel was developed in the fractured zone. When the flood subsided, the normal glacial Columbia abandoned its former Lower Coulee course and became located where Lenore, Blue and Park lakes now lie. Dry Falls and its associated features took origin near the head of Park Lake and in their present form are a product of the glacial Columbia after the flood subsided.

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SEPTEMBER
1932
Vol. VI Number 3

73
187

Published by
The
Northwest Scientific Association
Single Copy Thirty-five Cents

NORTHWEST SCIENCE

A scientific journal published quarterly by the Northwest Scientific Association and devoted to the dissemination and promulgation of scientific effort in the Pacific Northwest.

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NORTHWEST SCIENCE

Entered as second class matter April 5, 1927, at the Post-Office at Cheney, Washington. Office of Publication, Cheney, Wash.

Published quarterly at a subscription price of $1.00 per year, which includes the membership dues of the Association. Non members $1.00 per year. Vols. I (1927), II (1928), III (1929), IV (1930), V (1931), complete, each $1.25.

Reprints of articles appearing in regular issues will be furnished to the author at the following rates, *provided they are ordered prior to the time of going to press.*

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Printing of plates extra, at actual cost

NORTHWEST SCIENCE

Vol. SEPTEMBER, 1932 No. 3

The Association is not responsible, as a body, for the facts and opinions advanced in the papers published by it.

EDITORIAL

A topic of prime interest to the members of the Northwest Scientific Association and one which calls for careful thought before action is taken at the December meeting has developed from the discussions held at Pullman in June of this year. The committee of one, who wishes to remain anonymous, and to whom the matter was referred by the group of officers present at the meeting, presents the following for the consideration of the membership. Further information concerning the details of the proposed amendment may be sent to the members in circular letters or may be printed in the December issue of Northwest Science.

"President Redman of the American Chemical Society calls scientific research America's greatest asset, and warns that unless governmental, educational and corporate effort are continuous in it, 'national decay lies ahead'. He says that in times of depression research is the 'intellectual gold mine'. As the Northwest Scientific Association is the largest and most representative organized group of scientific workers in the Northwest it must bear a heavy responsibility for continuous effort in research in the region served by it. Reduction of budgets may not always be made with full recognition of the value of what is destroyed. In 1926 the Association began a movement to incorporate in order that it might legally accumulate funds to aid research. In 1928 incorporation was completed and three trustees were elected. Up to the present that is as far as the movement has gone. At the luncheon of the officers of the Association at Pullman in June, a committee of one was appointed to present an amendment to the constitution which should define the areas of activity of the Board of Trustees and the Council with a view to getting effective action in securing means of support for the Association in 'the Promotion of Scientific Research and the Diffusion of Scientific Knowledge'.

"The committee's report is far-reaching in its efforts. It defines the duties of the Council, which are little changed from what they have been in the past, but to the Board of Trustees it assigns duties which if adopted, will virtually make it a 'Regional Research Council', with duties of securing funds for the aid of research in the educational institutions and other agencies for research and for private effort as well. The board is enlarged and divided into three groups, in selection at least. An advisory scientific group, an advisory publicity group, and an executive group to function when the Board is not in session. The

Board is charged with the duty of attacking the situation of research in the Northwest, deplorable in so far as support of private wealth is concerned. Giving wide publicity to comparisons with the situation in other sections may be one of its chief weapons.

"The most important business of the next general meeting, December, 1932, may be the selection of the new Board of Trustees. This is the belief of the committee. Langley built a flying machine and died because it wouldn't fly. Orville Wright flew it. The committee fully realizes that the success of its effort will depend on the crew with which its 'machine' is manned."

Respectfully submitted,
Commitee on Constitutional
Amendment.

Higher Efficiency in Domestic Heating[1]

by

HOMER J. DANA *and* H. H. LANGDON

State College of Washington

THE modern watchward is "Increased efficiency," and there are few places more fertile for work along this line than the domestic furnace. One would not tolerate for one instant having the fireman throw one or two shovel-fulls of coal into the ash can for every three placed in the furnace, yet that is just what happens in a large percentage of domestic furnaces. When the fire burns low, a large supply of fuel is piled onto the hot coals, resulting in a dense smoke—unburned fuel escaping up the chimney—later to smudge the family wash on the line. On its way out, this smoke leaves a heavy coating of soot on the inside of the furnace walls—a first class heat insulator which serves to prevent the heat of combustion from escaping from the furnace except up the chimney. This results in a high chimney temperature which again indicates lost heat value. Personal attention by the firemen to good firing methods will serve to reduce this waste somewhat, but at the very best, hand firing quickly reaches an irreducible minimum of waste which itself is far too high.

If one were to select a number of hand fired domestic furnaces at random and measure the efficiencies, probably none of these would be found to exceed 50 per cent. Most furnaces would be found to operate at much less that the above figure, say an average of 30 to 40 per cent. Assuming that a coal bill amounts to $200 per year, then on the basis of 50 per cent efficiency, only $100 worth of the fuel actually serves to make the residence a pleasant place in which to live.

In order to ascertain the amount of preventable waste taking place in domestic furnaces, a series of experiments was undertaken by the Engineering Experiment Station of the State College of Washington. The work for the data in this paper was confined primarily to two furnace installations in two separate but comparable residences. Both heating plants were hot water systems and were fired with stokers. The use of stokers is recognizezd by combustion engineers as affording opportunity for considerably higher and

[1]Presented at the Annual Meeting of the Northwest Scientific Association, December 29-30, 1931, Spokane, Washington.

more consistent efficiencies in fuel burning than is possible with hand firing. Inasmuch as the public is, as you might say, rapidly becoming stoker-conscious, it is felt that this system of burning coal will become increasingly more common during the next few years.

Tests on these two stoker installations soon revealed that the average operating efficiency to be expected from the usual type of domestic heating plant equipped with stoker would not exceed 50 to 60 per cent.

There is no question but that fault can be found with the combustion

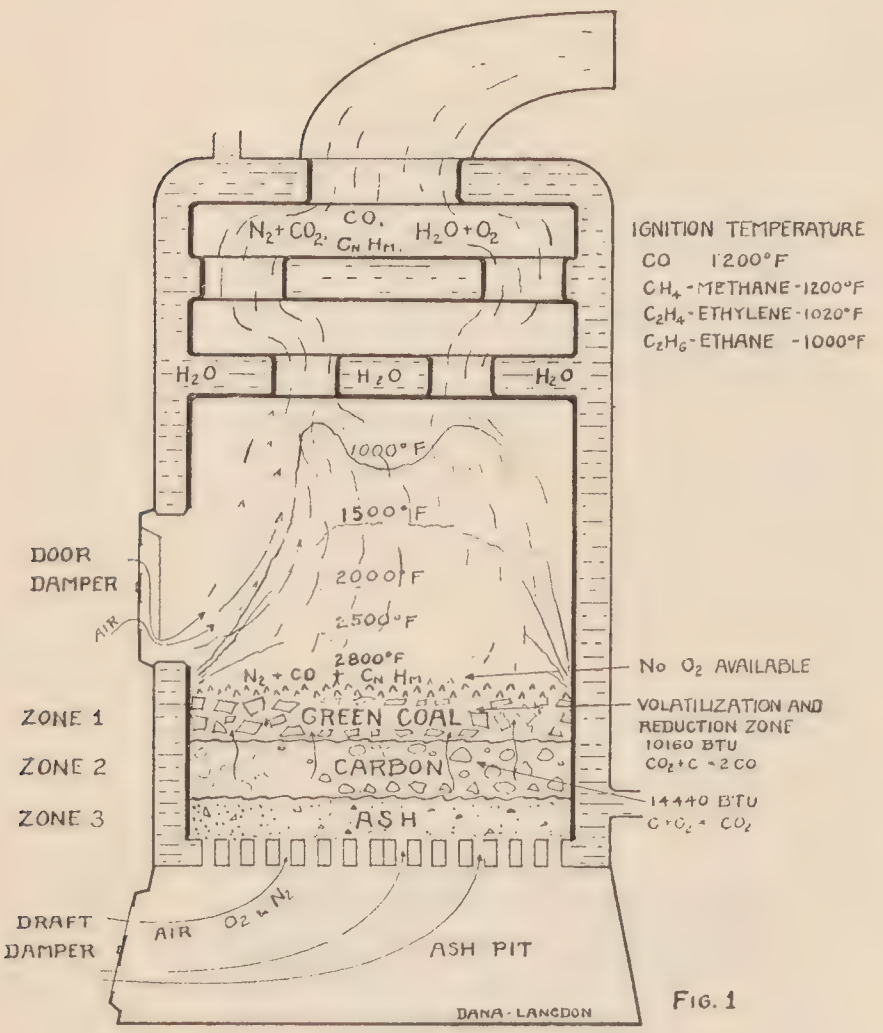

FIG. 1

chambers of most of the hot water, hot air, and steam boilers and furnaces at present on the market and in use. The hot water and steam boilers especially defy the principles of combustion as they are laid down by the chemist and the experience gained in many years of power plant development.

In order that we can understand these principles it will be necessary to study in detail the combustion processes for hand firing and stoker firing in a typical hot water boiler and furnace.

Figure I shows a typical cast iron hot water boiler with water legs and cast iron sections with gas passages above the combustion chamber. This illustration also shows the fuel on the grate for hand firing as well as the "Combustion zones," the reactions and heat liberation for each zone, and also the various gases that are evolved as well as isothermal lines above the fuel bed. (The isothermal lines are not drawn from data obtained in these tests)

The following discussion of this figure is based on the theoretical case; that is, (1) a uniform fuel bed is maintained, (2) fresh fuel is placed on the fuel bed at frequent intervals and is spread uniformly over the bed.

Air is introduced through the ash pit damper and passes up through the grate. It passes through the ash zone which is immediately above the cast iron grate, and is raised in temperature by absorbing heat from the ash or clinker.

Bituminous coal which has been subjected to intermediate and high temperatures volatilizes and gives off approximately 50 per cent by weight of its total combustible matter, volatile gases or hydro-carbons. As this volatilization occurs shortly after the fresh fuel has been added, this process is confined to the top of the fuel bed or in zone 3. Therefore zone 2 must exist above the ash zone where pure carbon or coke is burned. Oxygen of the air coming up from below unites with the carbon in this zone and forms CO_2 and liberates 14,400 B.T.U. per pound of carbon burned.

The thickness of zone 2 or the zone of complete combustion depends entirely upon the quantity of air admitted below the fuel bed. In fact, Pro-

fessor Gebhardt in his book "Steam Power Plant Engineering" has shown that in fuel beds of reasonable depths (about six inches) and for drafts that are usually had with hand firing, the top of zone 2 is not more than four inches from the top of the grate. If less draft is available then zone 2 becomes thinner regardless of the amount of fresh fuel on top of the fuel bed.

From chemistry we know that CO_2 in the presence of excess carbon and high temperature reduces to CO ($CO_2+C=2CO$) with the absorption of 10,160 B.T.U. per pound of carbon. This means that above zone 2 we have a reduction zone or zone 3.

From the reactions already given no free oxygen can pass from zone 2 to zone 3, and therefore CO_2 and N_2 are the only gases that pass from zone 2 to zone 3. The N_2 passes through all zones and the furnace to the stack as inert gas. The CO_2 in passing through zone 3 is partially reduced with the absorption of heat and a lower temperature of the fuel in this zone results.

Volatile matter is distilled in zone 3 so that issuing from the fuel bed into the furnace volume we have CO_2, CO, and CnHm (Hydro-carbons), H_2O and N_2. (Notice especially that we have two combustible gases and no oxygen coming from the fuel bed to burn these gases.)

It is most important to observe that at the top of the fuel bed less than one-half of the total heat of the coal has been liberated, that the remainder of the heat is in the combustible gases, CO and CnHm, that the air for their combustion must come from some source above the fuel bed, and that this air must become well mixed with the gases before they can completely burn.

Referring to figure I air admitted at the firing door does not have a good opportunity to mix with the combustible gases before the gases are cooled below their ignition temperature which ranges from 1,000 to 12,000° Fahrenheit for the various hydro-carbons and CO present.

In other words, with the usual type of house heating furnace the secondary air admitted above the fuel bed is not thoroughly mixed with the combustible gases before they have been cooled below their respective ignition temperatures due to the relatively cool surfaces surrounding the combustion chamber and they pass out unburned

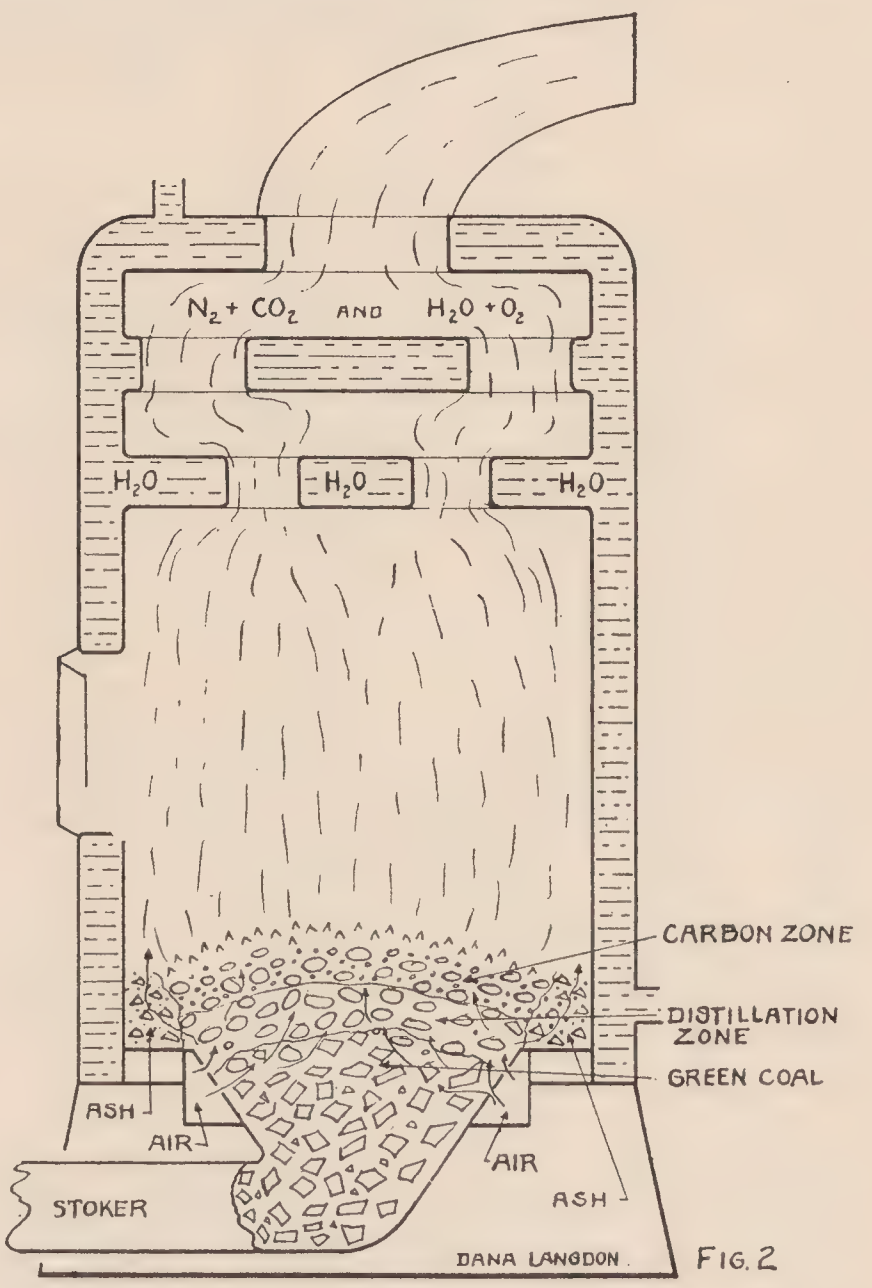

FIG. 2

producing an objectionable smoke and soot with low efficiency of combustion.

Professor Gebhardt also expresses a criterion of complete and smokeless combustion, which is as follows: "Whatever may be the nature of the fuel or the conditions of operation, for complete and efficient combustion the furnace must be constructed and

operated in such a manner that the combustible gases will be brought into intimate contact with the proper amount of air and maintained at a temperature above the ignition point until oxidation within the combustion zone is complete."

The writer believes that in the hand firing of a furnace as illustrated in Figure 1, combustion cannot be carried out in such a manner that this criterion is fulfilled, resulting in the waste of fuel, and in the production of objectionable smoke and soot. The furnace design is essentially at fault and the loss cannot be entirely overcome by various methods of firing that are in use by many householders.

The underfeed stoker does offer a real investment however, because of its inherent design and method of feeding fuel and air for combustion. In figure 2 a stoker is shown installed in the same type of furnace considered in the previous case. It will be noticed that coal is fed by a worm from below the fuel bed. Also air is introduced through tuyeres below the carbon zone.

In this case the carbon is on top of the fuel bed. The ash or clinker collect at the edges of the fuel bed. The fresh coal coming up from below approaches the high temperature carbon zone slowly and gradually. The volatile gases and air are mixed below the carbon zone and must pass through this high temperature zone. This is an ideal condition for the complete and sootless combustion of these gases. Now if the air is fed in, in proper proportion to the coal, no reduction zone will exist and oxygen can be passed through the fuel bed. As the gases evolved need time for their complete combustion, we find that CO_2, CO, and CnHm, H_2O, and N_2 will rise from the fuel bed. The CO and CnHm are in far smaller proportion than with hand firing the same amount of fuel. Consequently the flame above the fuel bed is short and the cool furnace walls are less effective in promoting poor combustion. There is no doubt that an underfeed stoker will produce better results in a given furnace than can be obtained with hand firing.

Tests conducted during the last two years have shown that ideal results can not be obtained without modifying the furnace design. As the air supply is reduced so that it approaches the theoretical requirement, the flame from the fuel bed becomes longer. The reason for this is that due to stratification of the gases leaving a coarse fuel bed, thorough mixing of the gas and air does not occur until there is considerable travel. It has been observed in a special furnace that with approximately 10 per cent of CO_2 in the flue gas a short flame existed; and when the CO_2 was increased to values approaching the theoretical for bituminous coal, or 18 per cent, the flame increased to a length of four feet or more. If the flame in this case had been surrounded by cold surfaces the flame would have been quenched and CO would have appeared in the flue gas analysis in appreciable quantities.

During the winter of 1930 tests were made on a hot water boiler and furnace such as could be considered typical of many hot water furnaces on the market or in use so far as test results are concerned.

As the water in a hot water system circulates due to the difference in density of the water before and after heating and the elevation of the radiators above the furnce, the forces causing circulation are very feeble. The water in the system does not have a velocity much in excess of twenty feet per minute at the most extreme conditions

of firing. Water meters that have been developed are not suitable for measuring the flow of water under such conditions. In order to determine accurately the heat balance at any time or for a short period of time it is necessary to measure the rate of flow of the water in the system. A water meter has been developed at the State College of Washington, which when inserted in a circulating system will measure the flow of water in that system at velocities as low as two feet per minute in a two-inch pipe and at the same time will not introduce an appreciable resistance to the flow. Interesting data in regard to the flow of water in hot water systems as well as short period and long period efficiencies have been obtained.

Many tests have been made of house heating boilers in manufacturers' plants and in laboratories under ideal conditions and for short periods of time, which show efficiencies that are relatively high,—say 60 to 70 per cent

These boilers when placed in the home and operated under normal conditions that are far from ideal have an efficiency over a twenty-four-hour period that may be quite low,—30 to 40 per cent.

Three tests will be given showing the efficiencies obtained in a six-room bungalow with full basement, the entire house being heated to a normal temperature of 70° Fahr. No effort has been made to alter combustion in the furnace to obtain excellent results; rather the idea has been to take the data of a day's heating cycle as it would be carried out whether the data were being taken or not.

In Test No. 1 the original hand firing grates were used. Ordinary lump furnace coal was purchased for the test. The house was naturally below normal temperature in the morning or at the beginning of the test. It was therefore necessary to fire quite heavily for about three hours, the fire was then allowed to die down until late afternoon when it was necessary to carry a medium fire to keep the house normal while the outside temperature was dropping.

The data for this test is as follows:

Average CO_2	3.85%
Maximum CO_2	8.50%
Average CO	1.55%
Maximum CO	2.8 %
Average Flue Gas Temperature	380°F.
Maximum Flue Gas Temperature	620°F.

Heat Balance:

Heat of the coal fired	750,000 B.t.u.
Losses:	
1. Sensible heat of flue gases	203,000
2. Due to combustion of hydrogen	39,000
3. Due to moisture in coal	3,300
4. Due to CO in flue gas	136,000
5. Unburned coal through grate	40,000

Heat recovered:

1. To radiators	200,350 B.t.u.
2. To hot water tank, estimated	29,200 B.t.u.
3. Radiated to furnace room	30,000
Useful, total	259,550
Percent useful heat	33.7%
Percent unaccounted for	9.3%

There are several points of particular interest brought out in this test.

First: The fact that during a day's heating, only 33.7 cents on the coal dollar is realized. This boiler when operated under ideal conditions in the laboratory or in the manufacturers' plant for a short period of time might produce 65 or 70 cents of useful heat out of the coal dollar.

Second: The CO_2 may be as high as 8.5 per cent for short periods while over the day's test it averaged but 3.85 per cent. This means that approximately 45 pounds of air was introduced for each pound of coal burned. The theoretical air per pound of coal is only 9 pounds. The coasting periods in a day's heating cycle are largely responsible for the extreme amount of air used and the large loss of sensible heat up the stack. The householder has little knowledge or opportunity to improve the firing.

Third: The loss due to the average value of CO of 1.55 per cent is 18 per cent of the total heat of the coal. The inherent design of the furnace is largely responsible for this loss.

Test No. 2

This test was conducted in the same furnace under the same conditions except that a stoker was used which was controlled by a thermostat in the living room.

Test Data:

Average CO_2	4.65%
Maximum CO_2	12.0%
Average CO	.8%
Maximum CO	1.7%
Average flue gas temperature	393° F.
Maximum flue gas temperature	625° F.

Heat Balance:

Heat of coal fired	930,000 B.t.u.

Losses:

Sensible heat of flue gases	260,000
Due to combustion of hydrogen	42,000
Due to moisture in coal	4,000
Due to CO	90,000
Total losses	396,000

Useful heat:

To radiators	385,000
To water tank	30,000
Radiated in furnace room	30,000
Total useful heat	445,000
Percent useful heat	48%
Percent unaccounted for	9.5%

There is a decided improvement in house heating cost shown by this test. The stoker uses a slack coal costing but two-thirds to three-fourths of the cost of the lump coal used in hand firing. In addition the efficiency is raised to 48 per cent as compared to 33.7 per cent for the same installation when hand firing.

Assuming lump coal to cost $12 and stoker coal to cost $9 a ton, one million B.t.u. of useful heat in the rooms will cost $1.36 for hand firing and $0.74 for stoker firing. This no doubt represents a good return on money invested in a stoker.

Both of the above tests show very large losses up the stack, first from sensible heat due to high flue gas temperatures, and second, due to the incomplete combustion of the gases that escape. The introduction of a stoker did not reduce the first loss as this is due to a lack of heat absorbing surface—a very common fault of house heating furnaces. The flue gas temperatures for a number of furnaces have been measured during the past few years, and the temperatures have been found to range from 500° F. to 1300° F. when the respective furnaces were operating under heavy firing conditions.

The introduction of a stoker did reduce the loss due to unburned gases up the stack. The better principles of combustion employed as illustrated in figure 2 are responsible for this.

An exceptional furnace designed on the basis of the criterion quoted from Professor Gebhardt's book, "Steam Power Plant Engineering" has been installed in the place of the furnace upon which tests 1 and 2 were made. This furnace is a radical departure from conventional design and has giv-

en some interesting results, as can be seen from test No. 3.

Test Data, No. 3:

Average CO_2	7.5%
Maximum CO_2	17.0%
Average CO	less than .1%
Maximum CO	.6%
Average Flue Gas Temperature	185° F.
Maximum Flue Gas Temperature	230° F.

Heat Blance:

Heat of coal fired ..515,000 B.t.u.

Losses:

Sensible heat of flue gases	22,500
Due to moisture in coal	1,900
Due to combustion of hydrogen	19,600
Due to CO	none
total losses	44,000

Useful heat:

Heat to radiators	375,000
Radiation to furnace room	50,000
Total useful heat	425,000
Percent useful heat	82.5%
Percent unaccounted for	10.0%

A real improvement has been brought about in two ways: first, the flue gas has been decreased in temperature to an average of 185° F. by better proportioning and arrangement of the heat absorbing surface. Second, better combustion has been obtained. No loss from CO or unburned gases is observable. Also the average CO_2 has been increased while the maximum value has approached within 1 per cent of the theoretical value for bituminous coal high in hydrogen.

The heating efficiency has been increased from 33.7 per cent for hand firing in test 1 to 48 per cent in test No. 2 to above 82 per cent for test No. 3. This brings the fuel cost from $1.36 for hand firing to 74c for test No. 2 down to 43c per million B.t.u. effective heat with the experimental furnace and stoker firing.

The above tests illustrate the possibilities for raising the efficiencies of domestic furnaces by improving the design of the combustion chamber and of the heat exchanger. The following test was made on a different hot water furnace of conventional make and design, and had for its purpose the determination of the preventable waste by means of adding an economizer to the original furnace installation. A twelve-inch duct, twelve feet long, was inserted in the flue gas passage between the furnace and the chimney so that the hot flue gases came into contact with approximately 371½ square feet of radiating surface before they passed into the chimney. This additional radiating surface was enclosed in a sheet iron casing with hot and cold air ducts leading to the living room above. A circulating fan was included in the cold air duct and adjusted to start and stop with the stoker. The resulting combination consisted essentially of a hot water furnace and a warm air furnace in tandem.

Tests on this combination yielded an overall efficiency during the operating period of the stoker of 90.8 per cent, and an efficiency of the hot water furnace alone of 74.6 per cent. Under these conditions the economizer yielded a saving of 16.2 per cent of the total heat of the fuel.

The above figures represent efficiencies obtainable during the operating period of the stoker. When the stoker shut down, there was still some unburned fuel in the firepot which continued to burn at a slow rate and with less perfect combustion. From the data taken over the entire period of one cycle—namely from the time the stoker started until it started again some

six hours later, the average overall efficiency of the heating plant was 87.2 per cent or a loss of 3.8 per cent due to the coasting period.

This calls attention to the desirability of operating a stoker continuously instead of intermittently, and of regulating combustion by varying the rate of fuel supply.

Briefly then, these tests have shown five things:

1. Hand firing in the usual type of household furnace yields a very low overall fuel efficiency, say from 30 to 40 per cent.

2. The use of a stoker will improve this efficiency between ten and twenty percent.

3. Replacing the conventional furnace with an improved design of furnace having better combustion space and more adequate heat exchanger gave an efficiency of 82.5 per cent—using less than half the coal to heat the same house in No. 1 at 33.7 per cent.

4. The addition of a hot air economizer to a conventional hot water, stoker operated furnace, yielded an overall average efficiency of 87.2 per cent, the additional heat being extracted from the flue gases.

5. High efficiency, namely 90.2 per cent, was obtained during the stoker operating period, but this was reduced by the long coasting period to an average of 87.2 per cent for the entire cycle—showing the desirability either of burning the fuel as fast as it is introduced, or of maintaining continuous stoker operation with varying rate of combustion.

Experiments at the Bureau of Standards show that cornstalks may be used to make a substitute for lumber, the annual report states. Subjecting a mat of the fibers, to heavy pressure gives a product which is hard, dense and strong, and equipment for semi-commercial production of this artificial lumber is being designed. Insulating wall board resistant to fire and water is already manufactured commercially from cornstalks. Wheat straw is under test as a possible source of paper, though results have not yet been entirely satisfactory. Sugars, which may find use in medical laboratories, have been prepared from cottonseed hull bran. Investigations are under way to find out whether a starch useful in textile industries can be gotten from sweet potatoes. A cheap, effective method of refining cottonseed oil has also been developed. Improved means of obtaining kraft paper from southern pine are likewise being studied.

Adaptation of Wheat Varieties in the Pacific Northwest[1]

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Introduction

THE wheat-producing areas of the three Pacific Northwest states lie principally in the region between the Cascade and Rocky mountains. The greater part of this extensive wheat belt is located in the direct path of the Prevailing Westerlies. These winds, coming from the Pacific ocean laden with water, lose much of their moisture as they pass over the great heights of the Cascade Mountains except where they go through the Columbia River canyon. The almost continuous flow of wind through this gap moves eastward, and is forced upward by the rising slopes of the Blue Mountains and adjoining plateaus. This humid air spreads out, and is deflected north or south by the local changes in storm areas. As a result of these increasing elevations, atmospheric conditions, and intermingling air currents, the Inland Empire receives an annual rainfall of from less than 10 to more than 25 inches.

It has been found necessary, in areas having less than 15 to 18 inches annual precipitation, to grow but one crop of wheat in two years, the land being in summer fallow during the intervening time to conserve moisture. In areas of greater rainfall, a crop can be grown each year by proper rotation. The increased yields of summer fallow land, when summer fallow is used in these more favored areas, result largely from the accumulation of nitrates as well as from the additional moisture conserved.

In order to obtain information concerning the distribution of wheat varieties in the Pacific Northwest a questionnaire was sent out to wheat farmers in the fall of 1929 by agronomists of Washington, Oregon, and Idaho. Approximately 2,000 replies representing 13 per cent of the crop were received. The figures for the total production by counties were taken from the census report for the 1929 crop while the variety distribution was taken from the questionnaire. From these two sources the distribution of varieties by counties was estimated. The detailed report is given for Washington in Bulletin 256[3] and for Oregon in Circular 97[4], and the data from Idaho was compiled from material furnished by H. W. Hulbert of the Idaho station.

More than two-thirds of the wheat grown in 1929 was of seven varieties which, named in the order of their importance, are Federation, Hybrid 128, Turkey, Baart, Fortyfold, Ridit, and Triplet. The completed surveys include the name, location, and number of acres and bushels of each of 66 varieties from which Table 1 was computed.

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[1]Presented at the annual meeting of the Northwest Scientific Association December 29 and 30, 1931, Spokane, Washington. Contribution from the Division of Agronomy, Farm Crops section, Washington Agricultural Experiment Station, Pullman, Washington. Published with the approval of the Director as Scientific Paper No. 236.

[2]Professor of Genetics in Agronomy and Professor of Farm Crops, respectively.

[3]Gaines, E. F., and Schafer, E. G., "Wheat Varieties of Washington in 1929." Wash. Agr. Exp. Sta. Bul. 256. July, 1931.

[4]Hill, D. D., "A Cereal Variety Survey of Oregon." Ore. Agr. Exp. Sta. Circ. 97. November, 1930.

Table 1. Varieties and Production of Wheat in the Pacific Northwest, 1929.

Variety	Bushels in Washington	Bushels in Idaho	Bushels in Oregon	Total bushels in 3 states
Albit	2,474,098	300,000	14,043	2,788,141
Arco			1,694	1,694
Baart	6,065,372	2,000,000	96,172	8,161,544
Big Club	11,270	50,000		61,270
Blue Chaff			91,930	91,930
Bluestem	1,633,634	500,000	61,776	2,195,410
Brown Squarehead	9,602			9,602
Bunyip	84,727			84,727
Burbank			50,014	50,014
California Glory	35,977			35,977
Club	87,442		24,323	111,765
Coppei	311,825	10,000		321,825
Currawa	15,400			15,400
Danube			2,830	2,830
Defiance			33,879	33,879
Dicklow	30,502	4,000,000	6,401	4,036,903
Durum	2,724			2,724
Early Wonder			73,057	73,057
Eaton			278,425	278,425
Federation	3,407,866	4,250,000	5,855,198	13,513,064
Foisy			87,460	87,460
Fortyfold	3,048,626	2,000,000	2,119,502	7,168,128
Galgalos			153,031	153,031
Hard Federation	294,656		131,346	426,002
Holland			955,055	955,055
Huston			187,258	187,258
Hybrid 63	122,415		64,114	186,529
Hybrid 123	458,987		7,030	466,017
Hybrid 128	5,577,602	1,000,000	5,026,762	11,604,364
Hybrid 143	111,027	500,000		611,027
Indian			656	656
Jenkin	1,071,484	2,600,000	658,955	4,330,439
Jones Fife	477,901	100,000		577,901
Kanred	32,898			32,898
Kharkof			18,449	18,449
Kinney			324,402	324,402
Little Club	56,589		44,402	100,991
Marquis	1,068,866	400,000	164,140	1,633,006
Mayview			13,245	13,245
Mosida	22,392	500,000	7,022	529,414
Onas			2,370	2,370
Odessa			51,009	51,009
Poole	19,611			19,611
Prohibition			123,790	123,790
Quality	88,416	20,000		108,416
Red Bobs	91,933	100,000		191,933
Red Chaff	111,305	150,000	9,704	271,009
Red Russian	460,486	1,800,000	23,142	2,283,628
Renfrew	8,395			8,395
Ridit	4,163,263	2,000,000	64,029	6,227,292
Rink			513,634	513,634
Royal			3,388	3,388
Ruby	10,120			10,120
Selection C	81,375			81,375
Sonora		100,000	47,831	147,831
Sun	35,931			35,931
Supreme	4,399			4,399
Thompson	1,023,186			1,023,186
Triplet	5,164,486	500,000	188,374	5,852,860
Turkey	4,405,675	3,000,000	2,868,820	10,274,495
White Amber			4,620	4,620
White Federation		10,000		10,000
White Odessa	2,802	20,000		22,802
White Winter			586,544	586,544
Winter Beardless			3,016	3,016
Zimmerman			99,932	99,932
Total	42,185,265	25,910,000	21,142,774	89,238,039
Total in census	42,588,762	28,590,857	21,526,667	92,706,286

The total production in this table is less than the total production of the three states because certain counties that produce very little wheat are not included, but all of the wheat produced in these counties amounted to less than four per cent of the total. Although many varieties are grown on a small scale, even these minor wheats taken all together are a great disturbing factor in the orderly marketing of the wheat crop. In summarizing the results of Table 1, it will be seen that 15 varieties are grown in all three states, seven are grown in Washington and Idaho but not in Oregon, and six are grown in Washington and Oregon but not in Idaho. One variety is grown in Idaho and Oregon but was not found in Washington. Washington has 12 varieties not found in the other two states, Oregon reported 24 that were not found in either Washington or Idaho, and Idaho has one not found in Oregon or Washington.

Winter and Spring Wheat Areas

Approximately 4,500,000 acres are sown to wheat each year and 4,000,000 acres are in summer fallow in the three Pacific Northwest states. These states produced 94,000,000 bushels of wheat in 1929, of which 59,000,000 bushels were from fall sowing and 35,000,000 from spring sowing.

The areas where fall wheat is sown are characterized by mild winters with sufficient rainfall in September and October to insure germination. Winter wheat is not commonly grown as far north in other parts of the United States as it is in the Pacific Northwest. Eastern Montana, the Dakotas, and Minnesota in the same general latitude are typically spring wheat states.

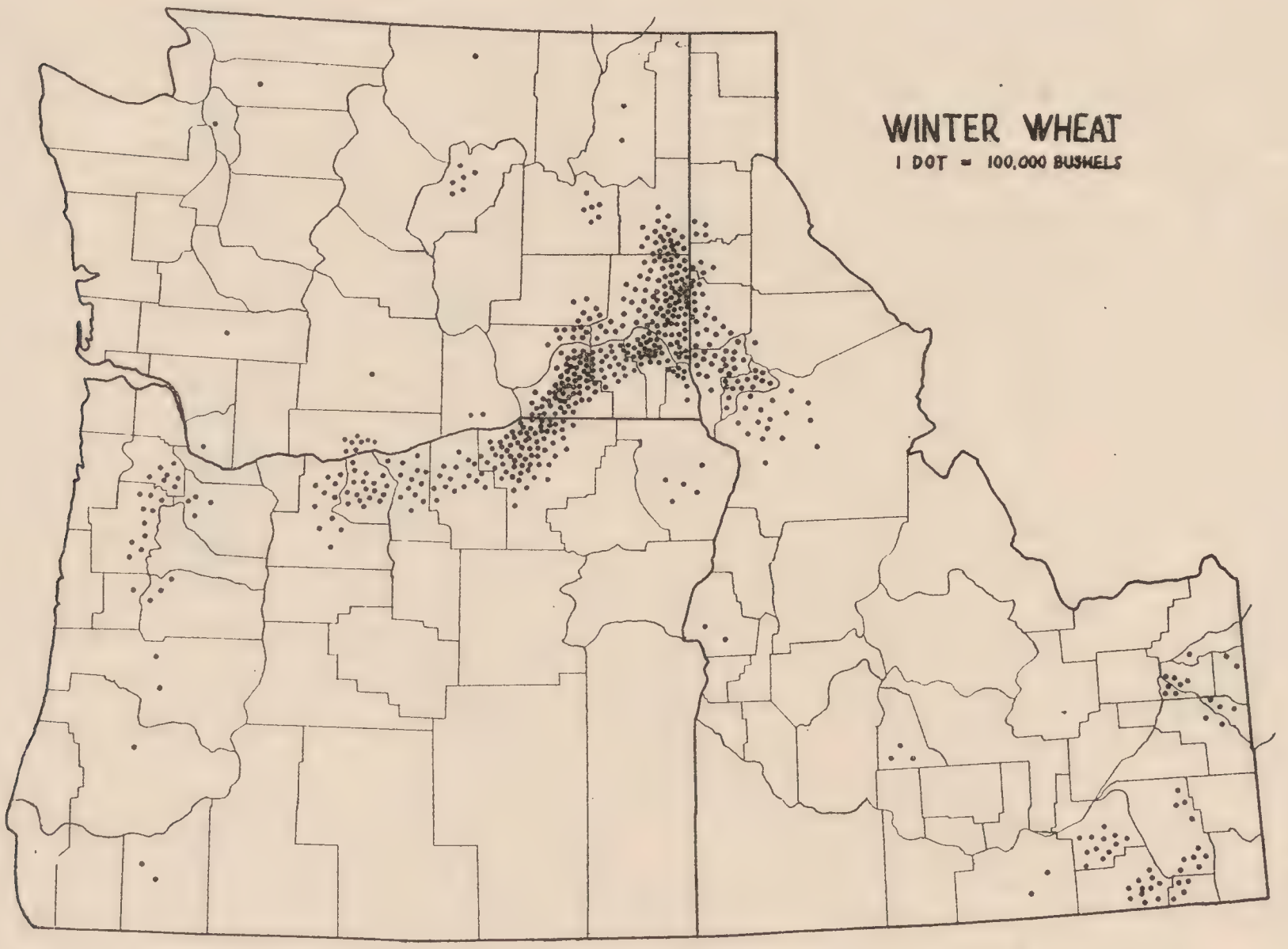

Figure 1. Location of winter wheat areas in Washington, Oregon, and Idaho. The warm, moist winds coming through the Columbia River canyon make an ideal climate for fall sown wheat.

Fall-sown or winter wheat is grown mainly, as shown in Figure 1, south of the Columbia River in Oregon and on both sides of the Snake River in Washington and northern Idaho. There is a winter wheat belt up the Willamette Valley of Oregon and a narrow strip is to be found north of the Columbia River in Klickitat and Benton counties in Washington, but the major winter wheat belt swings northward from the northern tier of counties in Oregon to the counties of Walla Walla, Columbia, and Garfield in Washington and, crossing the Snake, extends along Franklin, the corner of Adams, and most of Whitman. In Idaho it includes the counties of Latah, Nez Perce, and Lewis. Another district that produces winter wheat is found in southern Idaho on the uplands south and east of the Snake River.

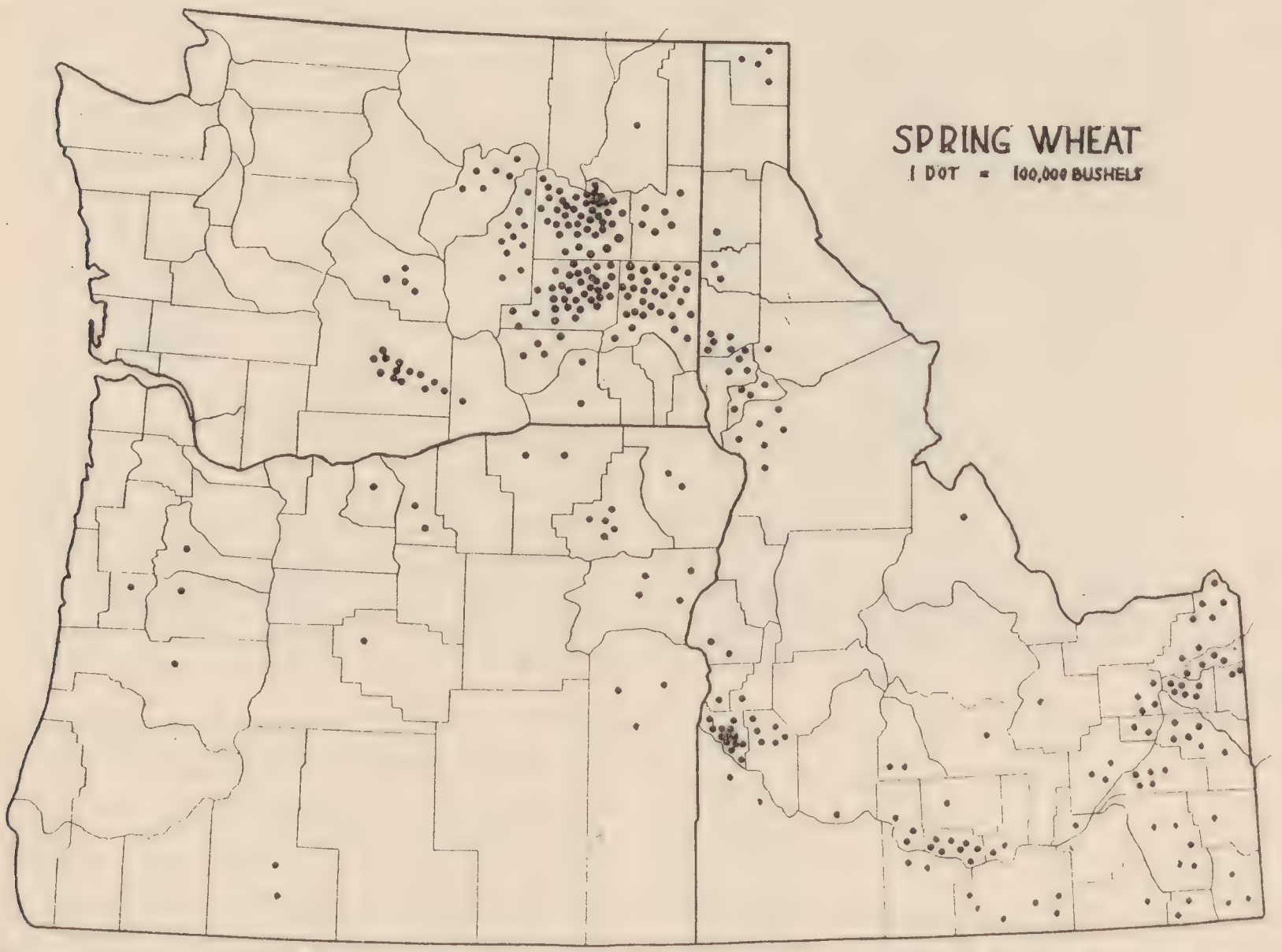

Figure 2. Location of spring wheat areas in Washington, Oregon, and Idaho. They are grown on dry lands or with irrigation where greater extremes of temperature than is favorable for winter wheat prevail.

In a general way the winter wheat belt is tempered by the winds from the Japan current that go through the Columbia River gap. Wheat seldom suffers from winter injury near the rivers even when there is no snow covering, although occasional winter-killing occurs if the temperature drops suddenly when the plants are in active growth or if an ice sheet forms in late winter. Alternate freezing and thawing breaks the roots and sometimes reduces the stand to the point where it is profitable to re-seed to spring wheat in March or April.

Small variations in temperature and moisture may make a decided difference in the suitability of a variety of wheat for a given location. For example, a snow covering of a few inches will prevent a non-hardy wheat from freezing when it would be killed without this protection. Other varieties may withstand the winters with or without snow. Hot winds during the ripening period will harm some varie-

ties more than others. The relative amount of cloudy weather while the grain is filling affects both the quantity and the quality of the grain.

Spring wheat (See Fig. 2) is grown under dry land conditions in the Big Bend country of central Washington, north and east of the Snake River where winter wheat predominates, and under irrigation in the Yakima Valley. The dry lands of the Big Bend are characterized by light rainfall, high winds, and hot summers. In southern Idaho spring wheat is grown under both dry land and irrigated conditions. It will be noted that the irrigated lands of Idaho are at a greater elevation than those of Washington although the rainfall is approximately the same. Comparatively little spring wheat is grown in Oregon.

As shown in Table 2, the amount of spring wheat varies considerably from year to year as a result of seasonal conditions, but averages about two-fifths of the total wheat. If the rains come late, as in the fall of 1917, the land may be held over for sowing in the spring. Occasionally severe winter killing occurs, and the fields have to be re-seeded in the spring. The high per cent of spring wheat in 1925 was the direct result of the unusual cold wave preceded by warm growing weather in late November of 1924. More than half the winter wheat area was re-seeded to spring wheat in Oregon and Washington, although Idaho wheat, protected by a snow covering, suffered but little.

Table 2. Per Cent of Winter and Spring Wheat and Total Production in the Three Pacific Northwest States (Washington, Oregon, and Idaho) from 1918 to 1931. Data from U. S. D. A. Yearbooks.

Year	Winter	Spring	Total
	Per cent	Per cent	Bushels
1918	44.8	55.1	59,700,000
1919	52.9	47.1	79,400,000
1920	54.1	45.9	84,482,000
1921	64.0	36.0	106,058,000
1922	63.8	36.2	76,463,000
1923	58.8	41.2	118,665,000
1924	62.8	37.2	60,578,000
1925	33.0	67.0	85,186,000
1926	55.2	44.8	84,240,000
1927	61.1	38.9	117,592,000
1928	65.7	34.3	100,754,000
1929	63.1	36.9	93,539,000
1930	60.1	39.9	92,590,000
1931	73.2	26.8	78,146,000
Average	58.5	41.5	88,378,000

Varieties Grown in the Pacific Northwest

The data on elevation, annual precipitation, and September-October precipitation for nine stations are shown in Table 3. It will be noted that the elevation at which wheat has been tested varies from 266 to 6200 feet, and that the annual precipitation varies from 8 to 41 inches. The September-October precipitation varies from 1.01 to 4.54 inches. The data were taken over a period ranging from 9 to 43 years. With such large variations in elevation and precipitation, and consequently in temperature, it would be expected that varieties of wheat differing greatly in their reactions would be required to meet the needs of the Pacific Northwest growers.

Table 3. Elevation and Precipitation at the Various Stations Where Wheat Varieties are Tested.

Station	Elevation	Annual precipitation	Sept.-October precipitation	Length of record
	Feet	Inches	Inches	Years
Pullman, Wash.	2,550	20.9	2.72	29
Lind, Wash.	1,475	10.6	1.27	25
Prosser, Wash.	661	8.0	1.11	9
Aberdeen, Idaho	4,400	9.0	1.01	18
Moro, Ore.	1,838	11.1	1.63	23
Sandpoint, Idaho	2,100	27.2	4.05	21
Felt, Idaho	6,200	13.2	2.34	11
Moscow, Idaho	2,748	21.7	2.85	39
Corvallis, Ore.	266	41.0	4.54	43

Figure 3 shows heads and grain of six leading winter wheats. Hydrid 128 has stiff straw, white grain, and does not shatter easily. Triplet has a nodding head with pubescent chaff and red grain. Turkey is bearded and has red grain. It lodges badly in areas of higher rainfall and greater soil fertil-

ity, but is sufficiently strong to stand where commonly grown. Ridit, noted primarily for its resistance to smut, has red grain which does not shatter easily. Fortyfold is noted for its stiff straw and large white kernels. Its greatest weakness is its tendency to shatter. Albit is much like Hybrid 128 in appearance, but has softer, more pliable glumes and straw, and greater resistance to smut.

Figure 3. Principal winter wheats of the Pacific Northwest. Left to right: Hybrid 128, Triplet, Turkey, Ridit, Fortyfold, and Albit.

The six leading spring wheats are shown in Figure 4. Baart has a very large white grain. It has a rather weak straw when grown in areas of greater rainfall, but stands well in the areas of less rainfall where it is commonly grown. The glumes of Federation are brown and the grain is white. Pacific Bluestem is tall, medium-maturing, and has white grain. Jenkin has glumes of a deeper brown than Federation, a club head, and white grain. Marquis has a head similar to Bluestem in appearance but has short red kernels. The grain of Thompson, or Pilcraw as it is sometimes called, is also somewhat smaller and softer than that of Bluestem.

The comparative yields of the 12 leading wheat varieties at five representative experiment stations are summarized in Table 4. The data were furnished by the various agronomists in charge of the variety testing: O. E. Barbee for Pullman, H. M. Wanser for Lind, H. P. Singleton for Prosser, D. E. Stephens for Moro, and J. H. Christ for Sandpoint. These men also discussed by letter or conference the characteristics other than yield that help to determine the economic value of the different varieties. Without the ready cooperation of the agronomists of the Pacific Northwest this study would have been impossible.

It is evident from Table 4 that winter wheats have yielded more than

Figure 4. Principal spring wheats of the Pacific Northwest. From left to right: Baart, Federation, Pacific Bluestem, Jenkin, Marquis, and Thompson or Pilcraw.

spring wheats. This is true at Pullman, Moro, and Sandpoint. At Lind, however, winter wheat did not survive every winter, and the comparison was made for only those years that winter wheat matured a crop. At Prosser under irrigation it is not practical to grow winter wheat.

Table 4. Comparative Yield of 12 Pacific Northwest Wheats in Per Cent of Hybrid 128. Averages of 8 to 15 Years.

Variety	Pullman	Lind	Prosser	Moro	Sandpoint
Winter					
Albit	105.6	109.5	91.4	90.2	117.7
Turkey	100.0	111.4	97.5	94.2	89.0
Triplet	102.7	97.2	98.2	97.1	99.8
Hybrid 128	100.0	100.0	100.0	100.0	100.0
Ridit	96.6	97.1	92.9	83.9	96.6
Fortyfold	80.5	56.3	77.9	79.1	92.1
Spring					
Federation	97.8	84.1	80.1	84.8	57.7
Baart	85.6	99.0	78.1	74.2	57.2
Jenkin	97.8		102.7		67.0
Bluestem	92.9	91.6	84.8	59.4	67.3
Dicklow	91.5		93.2	69.2	52.5
Marquis	83.9	82.7	73.0	65.8	59.7

It will be seen that a variety which does well at Pullman produces a relatively low yield at some of the other stations. Albit, for example, has produced the largest yield at Pullman and Sandpoint but has done poorly at Prosser and Moro. Turkey has produced the highest yield at Lind and the lowest of the winter wheats at Sandpoint. Of the spring wheats, Federation has produced the highest yields at Pullman and Moro, while Baart has produced the highest yields at Lind. Jenkin is highest at Prosser. However, yield is not the only criterion of the value of a variety. For example, at Moro Hybrid 128 outyields Turkey but is not as valuable because it shrivels badly when grown under conditions of light rainfall. It will be seen that Fortyfold and Marquis are low at all stations, and it can be safely predicted that they will decline further in importance.

Table 5. Change in Wheat Varieties of Washington.

Variety	Percentage of total production Average of 1918-1919	1929	Gain	Loss
Winter				
Hybrid 128	11.1	13.1	2.0	——
Triplet	——	12.1	12.1	——
Turkey	7.2	10.3	3.1	——
Ridit	——	9.8	9.8	——
Fortyfold	8.6	7.2	——	1.4
Albit	——	5.8	5.8	——
Jones Fife	2.9	1.1	——	1.8
Red Russian	5.9	1.1	——	4.8
Hybrid 63	2.3	.3	——	2.0
Hybrid 143	3.3	.3	——	3.0
Total winter	41.3	61.1	19.8	——
Spring				
Baart	15.9	14.2	——	1.7
Federation	——	8.0	8.0	——
Bluestem	16.5	3.8	——	12.7
Jenkin	8.8	2.5	——	6.3
Marquis	10.0	2.5	——	7.5
Thompson	——	2.4	2.4	——
Hybrid 123	1.7	1.1	——	.6
Dicklow	1.6	.1	——	1.5
Total spring	54.5	34.6	——	19.9

Table 5 shows the percentage of the total crop of Washington of 10 winter and 8 spring varieties grown in 1929 with gain or loss since 1918-1919. The 1918-1919 data were taken from Washington Bulletin 159 and the 1929 data from Bulletin 256. It will be seen that the five new varieties, Thompson, Federation, Triplet, Ridit, and Albit, representing 38.1 per cent of the 1929 crop have appeared during the last 10 years. During the same period Bluestem, Jenkin, Marquis, Red Russian, Hybrid 143, and Hybrid 63 lost 36.3 per cent of the 1918-1919 production. Although Washington produced 11,646,000 bushels more in 1929 than the average of 1918-1919, these six varieties produced 11,561,000 bushels less in 1929 than in 1918-1919. The five new varieties contributed 16,232,000 bushels to the 1929 crop.

The passing of certain wheats and the appearance of new varieties during a period of 10 years is only a part of a continuous process. Certain varieties are continually increasing while others are decreasing in the relative amounts grown. Varieties are discarded and their places are taken by others that are more satisfactory. This change occurs as a result of the introduction or production by hybridization of varieties better adapted to the environment and needs of the farmer.

Discussion

The greater part of the winter wheat is sown on summer fallow land. In the drier areas Turkey is grown almost exclusively since it seems best adapted to produce a crop under conditions of drought and cold. As shown in Table 1, it is produced in all three states in quantity. It is grown along the plateaus of the Columbia and Snake rivers, and in favorable years extends north into the spring wheat area. In the areas of higher rainfall where the winters are quite severe, Hybrid 128 reaches its best development. It has long been a popular wheat in the Pendleton and Walla Walla sections. Fortyfold has come to be grown at higher elevations where there is a snow covering during most of the winter. Triplet is widely grown in the sections between the Snake River and Blue Mountains in Washington. Jenkin is most important in northern Idaho. It was formerly grown in the Walla Walla country, but has been replaced by Triplet and in the last two years has further been reduced by the introduction of Albit into this territory.

The introduction of Federation from Australia 10 years ago marked a great change in the wheat varieties grown in the Pacific Northwest. From Pendleton north as far as the Snake River, Federation is sown in the fall in a great majority of cases, although it is typically a spring wheat and is not winter hardy north of the Snake River. It would thus be listed as a fall-sown wheat south of the Snake while in the Palouse country it is grown only from spring seeding.

In the early days the Big Bend was known as the Bluestem territory, but

during the last 15 years Baart has largely superseded Bluestem, as is indicated in Table 5. Baart was brought from the dry table-lands of Australia, and is by far the best adapted wheat that has been found for the Big Bend country. Not only will it produce satisfactory yields when other wheats are seriously injured by the hot winds, but the grain is of fine quality for bread making. It usually brings a premium over all the other varieties of wheat in the Pacific Northwest, sometimes as much as 20 cents per bushel over the best winter wheats. There are certain sections of southern Idaho where Baart does well, and they might be considered typical spring wheat areas. These areas are scattered and small, however, compared with the large acreage of the Big Bend. In the northern and eastern part of the Big Bend, Bluestem is still grown in considerable quantities, mainly in Douglas and Lincoln counties of Washington.

Occasionally this Big Bend area receives sufficient moisture in September to warrant sowing winter wheat, in which case a large acreage of Turkey is sown. It is doubtful that this practice is advisable even though a large yield is obtained, for the higher price for Baart offsets the greater yield that might be obtained in such seasons with winter wheat.

Dicklow is by far the most important wheat grown under irrigation although considerable quantities of Jenkin and Federation have been grown in recent years. The tests at Prosser, Washington (See Table 4) indicate that Jenkin yields more per acre than the other varieties, while the tests at Aberdeen, Idaho, seem to favor Federation. During the last 12 years Federation has yielded 3.6 bushels per acre more than Dicklow at Aberdeen. The wheats grown under irrigation are characterized by low gluten and soft texture. The Dicklow type of wheat, according to millers' statements, is much in demand for the pastry and cake trade because it produces a whiter flour than most wheats.

Both spring and winter wheats are common in Whitman and Spokane counties of Washington and in the adjacent counties to the east and south in Idaho. This area has a rainfall of from 16 to 25 inches with much snow in winter and fairly cool summers. In the intermountain areas, early varieties are important on account of early frosts. In the tests at Pullman, which lies within the area just described, the yields of the six leading winter wheats have exceeded the yields of the six leading spring wheats by only two and one-half bushels per acre. Whether the grain of the region be sown in the spring or in the fall therefore becomes largely a matter of convenience. Only hardy winter wheats are sown in the fall since varieties such as Federation and Jenkin very often freeze out while such varieties as Fortyfold, Albit, Ridit, and Triplet survive with perfect stands. During 1931 and in the sowings for 1932 Albit has become the predominating wheat for this area. It is estimated that more than 8,000,000 bushels of Albit will be harvested in 1932. Federation is the leading spring wheat in this area. Jenkin and Marquis are also to be found here and there, but they are grown much less than in previous years. Red Russian was formerly the predominating winter wheat, and is still grown in considerable quantities in Latah and Benewah counties of Idaho.

There are but four wheats of major importance in eastern Oregon. They are Federation, Hybrid 128, Turkey, and Fortyfold. (See Table 1).

The Pacific Northwest wheats are classified according to Federal Standards in Table 6. The commercial class or subclass to which a variety of wheat belongs is determined in part by variety and in part by environment. The adoption of Federal Standards has greatly facilitated the marketing of Pacific Northwest wheat. Perhaps one-third of the wheat raised in Washington, Oregon, and Idaho can be considered good for bread. Nearly one-half is utilized for pastry, cake, cracker, and biscuit flour, and for blending with the higher quality wheats. The remainder is used for seed, feed, and miscellaneous purposes.

Table 6. Fourteen Principal Wheat Varieties in Washington, Oregon, and Idaho Classified according to Federal Standards.

Class, subclass and variety	Production in 1929	
	Bushels	Per Cent
1. Hard Red Spring		
Marquis	1,633,000	1.8
III. Hard Red Winter		
Turkey	10,274,000	11.1
Ridit	6,227,000	6.7
IV. Soft Red Winter		
Triplet	5,853,000	6.3
Red Russian	2,284,000	2.5
V. White Wheat		
Hard White		
Baart	8,162,000	8 8
Bluestem	2,195,000	2.4
Soft White		
Fortyfold	7,168,000	7.7
Federation	13,513,000	14.6
Thompson	1,023,000	1.1
Dicklow	4,037,000	4.4
Western White		
Hybrid 128	11,604,000	12.5
Jenkin	4,330,000	4.7
Albit	2,788,000	3.0
Other varieties	11,615,000	12.5
TOTAL	92,706,000	100.0

Conclusion

There are approximately 40 testing stations in the Pacific Northwest where agronomists are accumulating comparative data regarding the adaptability of many varieties. Only those few that consistently remain near the top are increased for distribution to farmers. Not only in the Pacific Northwest, but throughout the world, there is a shift towards improved varieties. In the United States change of varieties has taken place in the last hundred years at the rate of about two per cent per year. The Pacific Northwest is a relatively new country. The first cargo of wheat from this area went out from Vancouver, Washington, a little over a hundred years ago. The present rate of production came in principally since the railroads were built, less than 50 years ago. Change of varieties since that time has occurred at the rate of about three per cent per year. There are indications that fewer varieties will be grown in the future than in the past and that, in considering the place of a variety, its reaction to climate will be one of the first considerations.

Certain sections such as the spring wheat belt of the Big Bend country are best adapted for growing bread wheats. Irrigated sections are well adapted for growing wheat suitable for cake and pastry flour. The winter wheat section may be divided into two parts, the Turkey district suitable for growing bread wheat and the more humid section best adapted for growing pastry wheat. The section where both winter and spring wheat grow well is also well adapted for growing pastry wheat.

The cooperation of the millers and bakers is needed in determining the final characteristics of the wheat to be produced. Agronomists can add their quota of information regarding the best rotation or fertilizing practice to maintain the standard quality of a given variety. Geneticists should put together the qualities that will better fit the new wheats to meet various requirements. Variety testing must be a continuous process to prove the worth of a new variety in any particular locality.

A Study of the Peroxy-Acids of Sulfur

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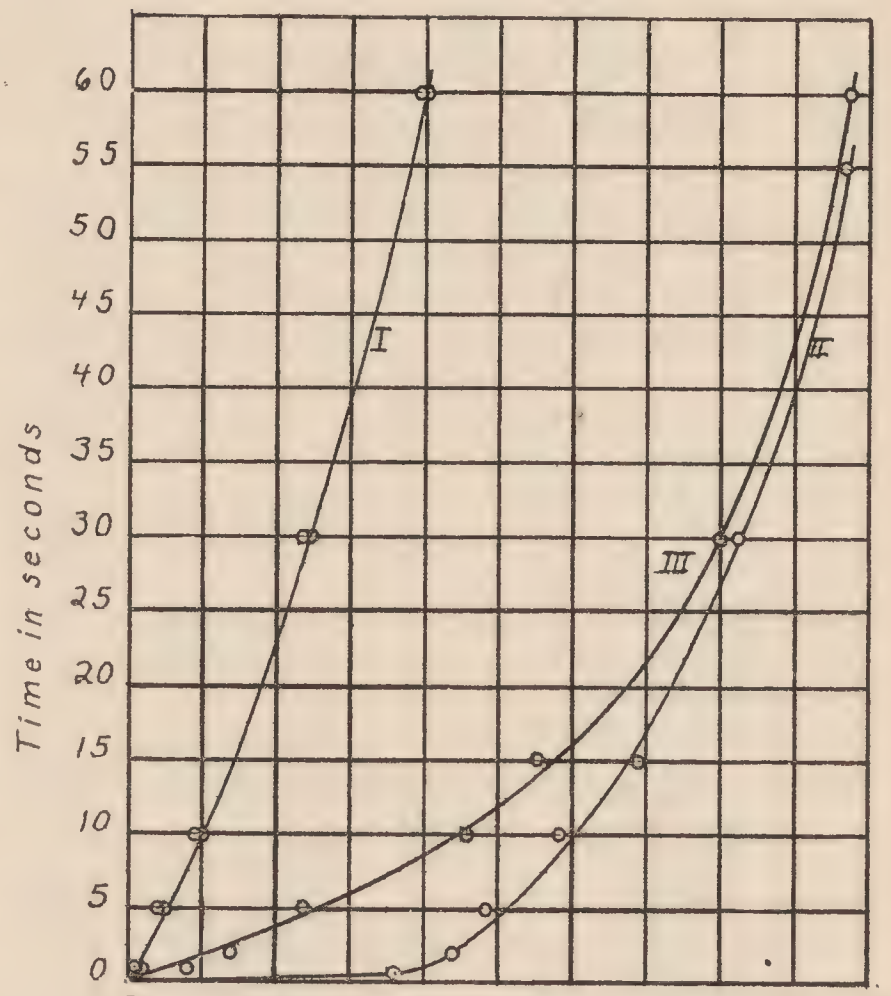
PREVIOUSLY reported experiments[1] have shown that tellurium can be oxidized to telluric acid by means of 30 per cent hydrogen peroxide and concentrated sulfuric acid. It was assumed, at the time when the experiments were made, that the oxidizing agent was permonosulfuric acid, as the solution of 30 per cent hydrogen peroxide in concentrated sulfuric acid had been shown by Bayer and Villiger[2] to contain this acid. However, Ahrle[3] had found that the perdisulfuric acid formed in this reaction, made the preparation of pure permonosulfuric acid by this means difficult, and that solutions of permonosulfuric acid invariably contain perdisulfuric acid. Others have reported that hydrogen peroxide alone will oxidize selenium to selenates and tellurium to the tellurate form[4]. Levi[5] found that the action of perdisulfuric acid on tellurium and selenium is to cause these elements to pass into solution as anions. Because of these findings it was somewhat doubtful that the oxidizing agent for tellurium in the previously reported experiments was permonosulfuric acid. With the view of determining which of the three (hydrogen peroxide, permonosulfuric acid or perdisulfuric acid) oxidizes tellurium to telluric acid, a short study of some solutions containing the peroxysulfuric acids was made.

To determine the oxidizing effect of perdisulfuric acid, a solution of potassium persulfate (8 grams per liter) in water was made. Portions of this solution were allowed to react with potassium iodide for different intervals of time, the liberated iodine being titrated with thiosulfate solution. The amount of oxygen available to oxidize

Figures I, II and III



potassium iodide during various intervals of time was thus determined. The results of this experiment are expressed as a curve in graph I of Figure 1.

The foregoing experiment was repeated, using the same quantity of persulfate dissolved in 40 cc. of concentrated sulfuric acid at 0° C. and diluted with ice water to one liter. The

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[1]Preliminary report, meeting of Northwest Scientific Association, December, 1929.

[2]Bayer and Villiger, Z. anorg. Chem. 32, 3625, (1899).

[3]Ahrle, J. prakt. Chem. 79, 129, (1909).

[4]N. W. Science, Vol. V, 86, (1931).

[5]Levi, Migliorni and Ercolini, reported by Mellor, "A Comprehensive Treatise on Inorganic and Theoretical Chemistry", Vol. X, 465.

solution so obtained was allowed to come to 22.5° C. Portions of this solution were allowed to react with potassium iodide as in the preceding experiment. The results of this experiment are expressed as a curve in graph II of Figure 1. Similar results were obtained when the acid used was phosphoric.

Another similar experiment was made, using a solution of persulfate in water, which solution had been allowed to stand at 0° C. for twenty-four hours. The solution was then allowed to come to 22.5° C. and portions were allowed to react with potassium iodide as in the previous experiments. The results of this experiment are expressed as a curve in graph III of Figure 1.

In all three of these cases the total available oxygen was liberated in five hours.

A solution of equimolecular quantities of hydrogen peroxide (30%) and concentrated sulfuric acid was prepared at 0° C. and allowed to react with potassium iodide solution. Nearly all of the available oxygen was liberated at once. A small amount of oxygen was liberated after two minutes. No more oxygen was liberated to oxidize potassium iodide after eight minutes, the solution being allowed to stand for twenty-four hours.

According to the literature, permonosulfuric acid liberates iodine from potassium iodide at once, or within two minutes, at 0° C. Therefore, the solution of hydrogen peroxide and sulfuric acid must have been composed almost entirely of permonosulfuric acid. We may also conclude from the preceding work that freshly prepared solutions of perdisulfates contain little, if any, permonosulfuric acid; that solutions of perdisulfates in sulfuric acid contain permonosulfuric acid, as do solutions of perdisulfates which have been allowed to hydrolyze.

Experiments with tellurium gave results similar to those in which potassium iodide was oxidized. The solution of perdisulfate in freshly prepared aqueous solution was without any immediate effect on tellurium. However, upon standing, such a solution oxidized tellurium slowly. A solution of perdisulfate in sulfuric acid oxidized tellurium much more rapidly than did the aqueous solution of persulfate. The solution of hydrogen peroxide in sulfuric acid oxidized tellurium rapidly when equimolecular quantities of hydrogen peroxide and sulfuric acid were present. However, when an excess of sulfuric acid was present (forming perdisulfuric acid) the oxidation was slower. When an excess of hydrogen peroxide was present, no increase in the speed of the reaction was apparent, rather, when a very large excess of the peroxide was present the action on the tellurium was slower, probably due to the diluting effect. Therefore, it was concluded that the oxidation of tellurium by solutions of hydrogen peroxide in sulfuric acid is due to the presence of permonosulfuric acid.

Training For Practical Citizenship[1]

By H. L. TALKINGTON
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IT has been well said that "Civics, like history, in the grades, has only within recent years advanced beyond the stage of utter neglect or perfunctory attention." It is true that a certain amount of time has been given to the study of the constitution of the United States, but this has oftentimes amounted to little more than the ability to name the qualifications, manner of election and the general powers and duties of the officers of the national government. Little or no attention has been given to the study of government as it is found in the family, the school, the city, the county or the state or to bring the individual into a realization of his personal responsibility to government wherever found.

In the United States, from the school district to the nation government, sovereignty is vested in the individual citizen, yet he has often received far too little practical education and training to fit him properly to exercise his sovereign power. Incidentally much valuable instruction in civics is received by the child everywhere. If he is taught to be obedient at home he will be orderly in school and law abiding when he leaves it; habits of industry, honesty and truthfulness formed in one place are likely to be practiced in another. But training for citizenship should not be incidental, it should be intentional, purposeful.

The great civic awakening, witnessed in the United States during the last few years, has not diminished the interest in the affairs of the national government, but rather it has widened the scope of the study of government in general and the part the individual citizen in particular plays in its administration. Civil government has come to mean citizen government, and this fact is everywhere recognized. A place for the work is being made in the course of study in our best schools; plenty of good books and suitable current literature may be obtained for every grade and there is a public demand for "Civic" education.

The late President Harrison once said "We stumble over the things nearest us" and Bryce, the author of "The American Commonwealth", speaks as follows on this same subject:

"An American may, through a long life, never be reminded of the Federal Government, except when he votes at presidential and congressional elections, buys a package of tobacco bearing the Government stamp, lodges a complaint against the postoffice, and opens his trunk for a custom house officer on a pier at New York when he returns from a tour in Europe. His direct taxes are paid in to officials acting under State laws. The State, or a local authority constituted by State statutes, registers his birth, appoints his guardian, pays for his schooling, gives him a share in the estate of his father, deceased, licenses him when he enters a trade, marries him, divorces him, entertains civil actions against him, declares him a bankrupt, and hangs him for murder. The police that guard his house, the local boards that look after the poor, control highways, impose water rates, manage schools,—all these derive their legal powers from the State alone. In comparison with such a number of functions the Federal Government is but a department for foreign affairs."

[1]Presented at the annual meeting of the Northwest Scientific Association, December 29-30, 1931.

If it be true that we stumble on the things nearest us and the things nearest us are our own state institutions, then training for citizenship should mean the becoming acquainted with these institutions. With this in view the material here presented will center around the following civil units: (1) the family, (2) the school, (3) the precinct, (4) the county, (5) the city, (6) the state.

The Family

If there be anyone who can claim such a thing as a divine right, it is the child. He would seem to have a divine right to good heredity and family training, yet the State of Idaho takes little precaution to insure him such things.

There is no literacy, financial, physical or intelligence test required for a marriage license. Practically anyone, 18 years of age who gives five days notice may enter into the holy bonds of matrimony. The only bars are those prohibiting relatives of a certain degree and the marriage of whites with negroes or Mongolians. When either party grows tired of family responsibilities, about all that is necessary is to bring suit to have the marriage contract annulled on the grounds of adultry, extreme cruelty, wilful neglect or desertion, habitual intemperance, conviction of felony, permanent insanity, or that the marriage was fraudulently contracted, there being five or six grounds included under this head.

About the only compensation for the misfit marriage is the lazy-husband law and alimony. Both are of very doubtful expediency and efficiency.

The children in the case of a broken family are usually left with the mother who can sometimes secure from the county a mother's pension amounting to $10 for the first child and $5 for each additional—Nez Perce county last year spent $6,550 for this purpose. Yet marriages, births, divorces and deaths go blindly on without much thought from the parties immediately concerned. Often the public in the end pays the bill for matrimonial failures.

Children's Home Finding Society

Here is where the State frequently pays part of the bill for its neglect. Two homes are maintained, one at Boise and the other at Lewiston. During the twenty-three years of the existence of these homes, about 5,000 children have been cared for.

On January 1st, 1930, there were 90 children in the Boise home and 51 in the Lewiston. During the year, 269 additional were received, making a total of 410.

Children are committed to these homes by order of the Probate court. Someone makes complaint, the sheriff serves a summons, for which he receives $10. If committed, the county pays $25 for admission and $10 per month per child for keeping. Other assignments may be temporary as when a family, in the death of one or both of the parents, cannot care for the children. One hundred such cases were received last year, and 95 out of the 100 were returned, 44 were released by parents. The majority of these were mere babes, and were illegitimate. The Superintendent says:

"Our present enrollment is 91 in the Boise Home and I think about 45 in the Lewiston Home. This includes 42 boys and 49 girls. The children are committed to our society through the probate courts of each county. They are committed either as temporary aid cases or permanent cases which will result in permanent homes. It is rather difficult to give you the approximate cost of keeping a child in our institution on account of much of

our expense being for field work and it is rather hard to segregate the expense. But a rough estimate would be about $150.00 a year."

"One hundred fifty-five children were placed in good homes, 57 of whom resulted in adoption. Most of these were under two years of age. It is difficult to find homes for older children."

The School for Feeble Minded

This school is one of the last established by the State and is located at Nampa, being opened June 9, 1918. According to the last report of the Superintendent of this institution, issued about December 1, the following represents the conditions of this home: the enrollment is 442, male 234, female 208; ages vary from 2 to 80 years; only about 15 per cent may be expected to be released; the annual cost to the State per day per person is about $0.50 (this does not include improvements); there are 30 employees; sterilization is functioning as far as funds will provide; present needs are a hospital, recreation hall and gymnasium.

The committment begins with a complaint by the proper person charging feeble mindedness. A warrant is then issued by the magistrate to the sheriff who brings such persons into court. Witnesses and a physician give testimony. When committed an attendant from Nampa comes and takes such person to the Home.

The boys are taught the care of the farm, livestock, and some of the simpler trades, while the girls are taught all sorts of home work. A school for the first six grades is maintained.

These people mentally are just children and must be protected, amused, and in every respect treated as such. Since only about 15 per cent may be released, the other 85 per cent are permanent charges to the state and this means that the number will increase annually.

Unfortunately about one-fourth of the enrollment are epileptics and should not be here, both for their own good as well as for the good of others.

The Soldiers' Home

Few other classes attract our sympathy so readily as the soldiers who have fought the nation's battles and in some way have been disabled. There are four classes of these; the Veterans of the Civil War, the Veterans of the Indian Wars, the Veterans of the Spanish-American War and those of the World War.

According to the last report of the commandant of this home (January, 1929), the membership numbered 85, whose average ages in the order mentioned, were 86, 71, 57 and 47.

Closely associated with the home is the Veterans' hospital where the old soliders are taken when in need of special nursing or a surgical operation.

The soldiers retain the pensions as their own property.

The School for the Deaf, Dumb, and Blind

It is the duty of the census marshal in each school district to secure the names, age, and sex of each hild who is too deaf, dumb, or blind to take advantage of the ordinary public school. These facts are reported to the county school superintendent.

In 1930 there were enrolled 102 pupils in this school; 80 in the department for the deaf, of whom 36 were girls and 44 were boys; 22 in the department for the blind, there being 4 girls and 18 boys. There are 144 blind people within the State.

These unfortunate people are given a home in the school located at Gooding, where educational advantages are

provided for them, both for grades and high school. Each student is taught those subjects best adapted to his condition, necessary to make him so far as possible self-supporting. It costs the State annually about $500 per person or about $75,000, but this is a good investment as it serves a double purpose of giving satisfaction to the pupil and enables him to make his own way in the world.

The Penitentiary

Few people have ever heard the story of the man behind the grey walls, for rarely does anyone go there unless forced to go and more rarely still does anyone who leaves there tell his story.

Of three hundred ninety men and women in the penitentiary at Boise, 58 were committed for forgery, 48 for grand larceny, 36 for first degree burglary, 16 for rape, and 13 for attempt to commit rape. Forty-nine crimes in all are listed.

Eighty per cent had never progressed in their education beyond the grades, while twelve per cent were college graduates. Twenty-one different religious denominations were represented, thirty-nine having no religious preference. Sixty four per cent were under forty years of age, and thirteen per cent under twenty. Sixty-four per cent left home before they were twenty years old. Fifty had been inmates of the Industrial Training School. Fifteen nationalities and thirty states were represented. Two hundred seventy-three were users of liquors. About thirty per cent are afflicted with venereal diseases, and be it said to the everlasting credit of the woman, that only two out of the 390 belonged to that sex.

Industrial Training School

Any boy or girl between the ages of eight and 18 may be committed to this institution till the age of 21. Good conduct will release such a person within 13 months, allowing him to be parolled, but still subject to the rules and regulations of the school. The average time served is 16 months.

The manner of committment is through complaint, trial before a probate judge and sentence by this officer. The expenses are borne by the county where the delinquent is tried, but the State bears the expenses of taking the child from the county to the institution. One hundred sixty-five children were brought before this court in Nez Perce county during the year 1931, but only three were committed.

The course of study for the eight grades is the same as that of the public schools, the children taking the same eighth grade examinations as are taken by other children. The term of school is ten and a half months. This leaves them time for a great deal of vocational study.

There is a farm of 651 acres with livestock, poultry, as well as truck gardens and shops of various kinds. All of the household work and the various economic courses usually found in a good high school are given for the girls.

The purpose of all the work is to equip the children with a vocation that will enable them to earn their own living when released from the institution.

The mental condition of the children is well shown from the Detroit Intelligence Test given them in 1930. The average median as given in these tests is—for Freshman, 84; Sophomore, 93; Junior 105; Senior, 116; these figures representing a good average for these grades. In the boys' eighth grade examination, 71 per cent were above the median of their grade, while in the high school in the line of retardation there were 42 per cent above average for those grades. While in

the case of the eighth grade it was found that 56 per cent were retarded.

It would seem that the failure of these young people is not intellectual, but moral and the lack of proper training, and the school seeks so far as possible to remedy these difficulties. But it is difficult to find good homes for them and they naturally long to return to their former homes and environments which are largely responsible for their down-fall.

Since the organization of this institution on January 3, 1905, 2,222 boys and 666 girls have been received by it. The number enrolled in the school November 30, 1930, was 203 boys and 61 girls, or a total of 264.

The 4-H Club

All boys and girls between the ages of 10 and 20 are eligible to membership in these clubs. This means that between fifty and seventy-five thousand children in the State of Idaho are eligible.

Kinds

Pig, sheep, calf, poultry, beef, colt, corn, potato, sugar, grain, garden, tomato, bean, forestry, home making, sewing, canning, food facts and home cookery.

The last biennial report of the Commissioner of Agriculture gives the following as the 16 leading lines of production of this State:

Hay	$30,000,000
Wheat	24,000,000
Sheep	23,000,000
Dairying	22,000,000
Potatoes	20,500,000
Beef Cattle	15,000,000
Poultry	14,000,000
Hogs	9,000,000
Apples	6,000,000
Beans	6,000,000
Barley	4,000,000
Sugar Beets	4,000,000
Peas	3,000,000
Oats	2,000,000
Corn	2,000,000
Cover and Alfalfa Seed	1,500,000

Value of Club

4-H Club work is a junior extension activity of the College of Agriculture of the University of Idaho. It is a publicly supported and directed educational enterprise of the United States Department of Agriculture with the State Land Grant College co-operating.

4-H Club work teaches, through doing, better practices in agriculture and home economics.

4-H Club work develops leadership, community pride and spirit, self-reliance, ambition and aggressiveness, and sportsmanship; above all, it develops the highest type of manhood and womanhood and American citizenship.

It teaches boys and girls how to meet together, work together, play together, and achieve.

The Club also encourages local exhibits, demonstration teams, educational days, club picnics, club songs and club yells, the cooperation of children and parents, practice in conducting meetings according to parliamentary law, create state-wide interest and cooperation, teaches the young people to judge and measure values, how to develop and care for any kind of activity in which the member may engage, unifies adult and child interest and activities, and stimulates initiative and competitive contests.

A Method for Rapid Estimation of Permono and Perdi-Sulfuric Acids and Hydrogen Peroxide In the Presence of Each Other

L. I. GILBERTSON
State College of Washington

A METHOD for the estimation of permono- and perdi-sulfuric acids and hydrogen peroxide, in the presence of each other, has been described by Palme (Z. anorg. allgem. Chem. *97*, 112, (1920)). The method is dependent on the fact that permono-sulfuric acid reacts at once with potassium iodide while hydrogen peroxide reacts much more slowly, and perdi-sulfuric acid slowest of all. Three samples are necessary for the analysis. One sample is added to a solution of potassium iodide and the liberated iodine rapidly titrated with sodium thiosulfate solution. The time needed for this titration is noted, as a correction is applied to account for the slight oxidizing effect of the hydrogen peroxide and perdisulfuric acid. The result of this titration shows the amount of permonosulfuric acid. A second sample is treated with potassium iodide and the liberated iodine is titrated with sodium sulfite solution to give the total combined amounts of hydrogen peroxide and permonosulfuric acid. The hydrogen peroxide is determined by difference. A third sample is treated with sufficient sodium sulfite solution to reduce the previously determined amounts of hydrogen peroxide and permonosulfuric acid, after which ferrous sulfate is added in excess and back-titrated with permanganate. Thus the perdisulfuric acid is determined by difference.

It is evident that this method is open to several objections:

1. The method requires the use of three samples.
2. The method is slow.
3. The necessity to note the time of titration of the first sample and the consequent application of a correction to the result, does not induce an accuracy sufficient to compensate for this added cumbersomeness.
4. The method is very likely to give high results for hydrogen peroxide and correspondingly lower results for permonosulfate.

In an effort to overcome some of these difficulties, and to make possible greater speed in analysis, the following method was devised:

1. Hydrogen peroxide is determined by direct titration with potassium permanganate. (Potassium permanganate does not react with peroxyacids of sulfur.) The sample is maintained at about 5° C. during this titration to prevent any great decomposition of persulfate.
2. Potassium iodide is added and the liberated iodine titrated with sodium thiosulfate solution. This result gives the amount of permono-sulfate present. The titration need not be made very rapidly if the solution is kept cold as the hydrolysis of perdisulfate is very low at low temperatures.
3. An excess of ferrous sulfate solution is added and back-titrated with permanganate solution. This titration need not be made in the cold. However, the solution need not be warmed for this titration as ferrous sulfate reduces the perdisulfate even at zero degrees centigrade. The result of the titration is perdisulfate.

This method has the advantage of being more rapid and quite as satisfactory as the Palme method. In using this method, results are easily reproducible.

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MOSCOW PUBLISHING CO.
Printers
MOSCOW, IDAHO

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APR 1 1933
NATIONAL MUSEUM

NOVEMBER
1932
Vol. VI Number 4

73
87

Published by
The
Northwest Scientific Association
Single Copy Thirty-five Cents

NORTHWEST SCIENCE

A scientific journal published quarterly by the Northwest Scientific Association and devoted to the dissemination and promulgation of scientific effort in the Pacific Northwest.

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NORTHWEST SCIENCE

Entered as second class matter April 5, 1927, at the Post-Office at Cheney, Washington. Office of Publication, Cheney, Wash.

Published quarterly at a subscription price of $1.00 per year, which includes the membership dues of the Association. Non members $1.00 per year. Vols. I (1927), II (1928), III (1929), IV (1930), V (1931), complete, each $1.25.

Reprints of articles appearing in regular issues will be furnished to the author at the following rates, *provided they are ordered prior to the time of going to press.*

Pages	2	4	8	12
100 copies without cover	$2.50	3.00	5.45	5.95
100 copies with cover		3.75	6.20	6.70
200 copies without cover	3.25	4.25	5.75	7.90
200 copies with cover		5.50	7.00	9.15
300 copies without cover	3.75	4.50	7.00	10.00
300 copies with cover		6.25	8.75	11.75

Printing of plates extra, at actual cost

NORTHWEST SCIENCE

Vol. VI. NOVEMBER, 1932 No. 4

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EDITORIAL

Another year is drawing to its close and, with this issue, Northwest Science has ended another period of service to the Association members. A service which is of necessity limited but which, nevertheless, is striving toward a larger and more active membership, a greater stimulation of scientific effort and a satisfactory medium of expression in the form of scientific articles. During the many years of its existence, Northwestern Science has been issued regularly at a minimum cost and due to the limited budget it has been impossible to print illustrations without calling upon the author to foot the bill. Our publication is no longer an experiment, it has survived all viscissitudes and is now prepared for a steady growth.

As a natural step in this growth, provision should be made in the forthcoming budget for sufficient funds to allow the author a certain minimum of illustrative material free of charge. This policy, I am certain, will aid greatly in attracting the best scientific papers of the Inland Empire region not excluding those papers written by investigators who, at the time, may not be members of the Association.

This brings to mind several points which should be presented to the membership in order to pave the way for a more efficient and satisfactory management of the journal articles during the coming year.

For publicity purposes all articles presented before the Association at the annual meeting should be carefully abstracted. The abstract should be prepared in newspaper style for the reading public, and should be sent to the Association secretary a week in advance of the meeting.

Copies of all papers, including illustrations, should be deposited with the secretary of the Association through the Section secretaries on the opening day of the annual meeting or preferably should be included with the abstract. This will greatly facilitate the preparation of papers for publication in Northwest Science. Papers are frequently received at the end of the year and are therefore too late to be considered in the last issue of the journal which has several of its pages reserved for the annual program.

The papers should be prepared in the general style indicated by the articles published in Northwest Science. Heading, author's name, institution and footnote indicating that the paper was presented at an annual meeting of the Association should be carefully noted. Graphs should be clearly drawn in black and white and neatly lettered and all photographs should be carefully titled and numbered.

If the paper is intended for publication in another journal or has already been published such a notation should be made on the copy left with the Secretary.

If these few suggestions are followed, the coming year should show a decided improvement in our publication and as a result we may find an increased interest in the activities of our Association.

Several Phases of Geology of the Moses Coulee Area[1]

by

MALVIN G. HOFFMAN

Washington State College

Introduction

MOSES Coulee and the adjoining area were studied during the summer of 1931 by a field party of the Washington Department of Conservation and Development[2] composed of Arnold D. Hoffman, M. A. Search, and the writer. The geology was done by the writer, the paleobotany by Arnold Hoffman,[3] and the plane table mapping and triangulation by both M. A. Search and Arnold Hoffman.

Bretz[4] has written several articles on the physiography of the scablands of central and southeastern Washington, Fuller[5] has described some structures in the lavas and basalt breccias, and A. C. Waters has submitted to Yale University a thesis on the southern half of the Chelan quadrangle which has not yet been published.

Figure 1. Map of Douglas County showing location of Moses Coulee.

Moses Coulee is a channel about 40 miles long located in central Washington near the western edge of the basalt plateau and about 60 miles east of the Cascades. It joins the valley of the Columbia in southwestern Douglas County and its general direction is northeast-southwest.

The coulee has a broad flat floor which averages one mile in width. The lower half ranges in depth from 600 to 1100 feet and the northern half

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[1]Presented at the Annual Meeting of the Northwest Scientific Association, December 29-30, 1931, Spokane, Washington.

[2]This report is published by permission of the Supervisor, Division of Geology, Department of Conservation and Development, Washington.

[3]The fossils which were collected from the sediments in Douglas Canyon have been described by Arnold D. Hoffman whose report will soon appear in the Journal of Geology.

[4]Bretz, J. Harlen, has written a number of articles on the scabland region of Washington, but those pertinent to this area are: Glacial Drainage on the Columbia Plateau, Bull. Geol. Soc. of America, Vol. 34, 1923, pp. 573-608; The Channeled Scablands of the Columbia Plateau, Jour. of Geol. Vol. 31, 1923, pp. 617-647; The Age of the Spokane Glaciation, Am. Jour. of Sci. Ser. 5, Vol. 8, 1923, pp. 336-342; The Channeled Scabland of Eastern Washington, Geog. Review, Vol. 18, No. 3, July, 1928, pp. 446-477.

[5]Fuller, Richard A., Aqueous Chilling of Basaltic Lava on the Columbia River Plateau, Am. Jour. of Sci., Vol. 21, 1931, pp. 281-300.

from 200 to 400 feet. Talus slopes, some as much as 500 feet high, lie along the walls. The talus is composed mainly of angular pieces of basalt from small fragments up to blocks seven or more feet in diameter. Most of the pieces range in size from 6 to 18 inches. The angle of repose is high, there being many slopes with a 38° dip. Along the side walls in the lower third of the coulee are a number of conspicuous hanging valleys. A few of the tributaries have cut canyons down to the present level of the Coulee floor of which Francis and Douglas Canyons are the most prominent. The main channel is now occupied by a small intermittent meandering stream.

Traced upstream back from the Columbia River the Coulee follows a northeastward course for 14 miles where it turns sharply extending eastward for 5 miles. Here it makes a second bend back to a northeastward direction and continues so for the remainder of its length, about 20 miles. The canyon is ill defined north of Jameson and Grimes Lakes. The first sharp turn is made where the Coulee crosses the Badger Mountain fold and the second at the Three Devils, so named from three sharp climbs made by a road which leads up out of the channel. From the Three Devils northeastward for about 8 miles the coulee is located in a broad synclinal valley. Near Spencer it crosses another anticlinal fold, but this time without changing its direction.

The recent drainage has cut through a gravel bar at the mouth of the Coulee where the average elevation of the floor is approximately 850 feet above sea level. Two miles up the canyon the floor drops to 816 feet and from here northeastward the grade is steadily upward. At the foot of the Three Devils the elevation is 1030 feet where an abrupt rise of 400 feet is made over a series of dry falls. From the top of the falls to Spencer, a distance of 9 miles, the rise is about 225 feet.

Stratigraphy

The oldest formation exposed in the Moses Coulee area is a 35 foot section of clastics in Douglas Canyon about one-half mile north of the coulee. Resting upon the sediments with apparent conformity is a 1900 foot series of basaltic lava flows broken in only a few places by thin layers of soil, clay, or arkose. Unconformably overlying the basalts are gravels, sands, silts, and glacial till, of glacial, glacial outwash and fluviatile origin.

The section of sediments underlying the basalt is a series of poorly indurated shales, arkosic sands and tuffs which range in color from light tan and buff to dark gray. About 11 feet from the top a dark gray carbonaceous shale yielded a number of plant fossils which were studied by Hoffman[6] who reported that they represent a flora identical with the one described for the Latah[7] near Spokane, Washington. Hoffman correlated the sediments in Douglas Canyon with the Latah and placed them in the late Miocene, which correlation corresponds with the regional stratigraphy of the plateau basalts.

In the Ellensburg Folio Smith[8] described two basalt series which are separated by the Ellensburg formation. The Ellensburg has been placed in the upper Miocene[9] along with the Latah and a number of other sedimentary

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[6]Hoffman, Arnold D., Loc. Cit.

[7]Knowlton, F. H., Flora of the Latah of Spokane, Washington and Coeur d'Alene, Idaho, U. S. Geol. Survey, Prof. Paper 140-A, pp. 17-81 (1925). Berry, E. W., A revision of the Flora of the Latah Formation, U. S. Geol. Survey, Prof. Paper 154-H, p. 235 (1929).

[8]Smith, George Otis, U. S. G. S. Ellensburg, Folio No. 86, p. 3 (1903).

[9]Berry, E. W., *Loc. Cit.*

sections in the Northwest. Smith named the lower series of flows the Yakima basalts and the upper series the Wenas basalts. His estimates of thicknesses are about 200 feet for the Wenas and at least 2000 feet for the Yakima. Outside of the Ellensburg area the two groups are referred to the Columbia River Lavas. The latter term is a very general one and even includes some flows which are now known to be much younger than Miocene, some even as late as Pleistocene.

In the summer of 1930 the writer made a reconnaissance study of the Atanum and Rattlesnake Hills southeast of the Ellensburg quadrangle and traced southeastward for about 40 miles the Yakima, Ellensburg, and Wenas formations. Near the northwestern end of Rattlesnake Hills the Ellensburg formation is well exposed, interbedded with a few layers of basalt and in places tilted as much as 80°. The overlying Wenas basalts thicken rapidly to the eastward and at about the longitude of Sunnyside reach an estimated maximum thickness of 1500 feet.

In the Moses Coulee area the basalt section overlying the sediments in Douglas Canyon measures 1900 feet. Hoffman's[10] correlation, which places the Douglas Canyon formation in the late Miocene and equivalent with the Latah, Ellensburg, and others makes it highly probable that the Moses Coulee basalts are Wenas. Waters mistakenly called this series of flows the Yakima basalts[11].

The Yakima basalts are not exposed in Moses Coulee but in all probability underlie the area and could be readily reached by the drill. The gas wells on the northeastern flank of Rattlesnake Hills penetrate basalt below the Ellensburg formation.

The coulee basalts are separated in a few places by thin sedimentary beds. At the lower end on the southern wall about 400 feet above the floor is a bluish gray clayey soil 2 to 3 feet thick which can be traced for about one-quarter mile. Along the same wall and about 6 miles above the mouth an arkosic layer can be seen as a white line paralleling the flows and about 500 feet above the channel floor. It varies in thickness from 2 to 4 feet and is visible for a distance of about a mile.

There is a mud-flow on the southeast wall of Moses Coulee, about five miles above its junction with the Columbia. It is exposed as a bench about three-eighths mile long and one-eighth mile wide with a vertical cliff 200 feet high. It is formed largely of a black tuffaceous rock containing many stringers and blocks of basalt of all sizes from very small to some 25 feet across. Toward the base are inclusions of light gray fine grained tuffaceous and arkosic sands. The largest one filled a pocket 8 feet by 4 feet by 3 feet. Some unidentifiable fragments of plant stems, leaves and tree trunks were found in them. The sediments were probably carried down from a horizon about 350 feet higher in the section. At that horizon nearby a thin interbasalt layer was found which closely resembled the inclusions. It also contained some bits of plant fossils which were too fragmentary to be determined.

The colors of the igneous rocks are dark reddish-brown, gray to dark gray, and black. Weathering produced most of the reddish colors but not all of the rocks take on this hue as a result of climatic activities. In some instances lighter or darker shades of gray oc-

[10]Hoffman, Arnold D., *Loc. Cit.*
[11]Waters, Aaron W., unpublished thesis submitted to Yale University.

cur, while in others no marked color change appears.

The basalts are present as overlapping layers and sheets from a few feet to over 175 feet thick, and are cut by dikes which mark some of the fissures through which the lava was extruded. If the distinct layers are used as a basis of separation the count in one place will be quite different from that a mile away. Within a short distance two layers may merge or one may be replaced by two. Where the dividing line is marked by a soil layer, a sedimantary bed, weathered surface, or scoriaceous surface, the observer can, with a considerable degree of confidence, make the separation.

Structure

The flows appear to have a regional southeasterly dip of 1 or 2 degrees but are warped by several anticlinal folds, two of which are quite distinct. The most conspicuous one crosses the coulee about 14 miles above its mouth in a direction N65°W. The greatest dip on its southwestern flank is 7° and that on the northeastern limb is 18°. A few large masses show dips as high as 45°, but these are slumped. This fold is one of the ridges of the Badger Mountains and its cross-section is excellently visible from within the coulee. In the axis of the fold the rocks have been raised at least 800 or 900 feet. This anticline is marked on the surface by a well defined ridge which can be followed for many miles.

A second and less conspicuous anticlinal fold strikes N60°E and meets the first in the neighborhood of the falls in Douglas Canyon. Due to the marked uplift caused by the cross folding the lowest rocks in the section are here exposed, the sediments underlying the basalts. The maximum dips of the flanks of this fold are about 5° and 7°, the southeastern flank being slightly the steeper.

From 5 to 6 miles south of Badger Mountains is another fold which parallels it but has low dips of 2° to 4°, the northeastern slope having the greater dip as is the case in the larger fold.

In the northern section of the coulee for several miles north and south of Spencer there are several minor flexures in the basalt.

All of the folds mentioned were formed coincidently with the Pliocene uplift of the Cascade Mountains and of the series of northwest-southeasterly ranges in central Washington.[12] Moses Coulee cuts across all of them and is evidently the enlarged descendent of an antecedent drainage channel.

Miocene History

The history of the area so far as can be determined from the exposures begins with upper Miocene when the Douglas Canyon sediments were deposited in a lake. It is thought that a group of lakes existed in the Northwest in late Miocene time. The lake deposits are of wide extent being represented by the Ellensburg in the Rattlesnake Hills, the Douglas Canyon formation in Moses Coulee, unnamed beds in Grand Coulee, the Latah in the Spokane region, the Payette in southwestern Idaho, and the Mascall in northcentral Oregon.

The Latah epoch was followed by the extrusion of a series of basaltic flows at least 1900 feet thick. The lava rests with apparent conformity on the sediments and is at least as widespread as the Latah and related formations.

[12]Smith, George Otis, Ellensburg Folio, No. 86, U. S. G. S. p. 2 (1903).

(Continued on page 129)

Russia[1]

By THOMAS T. KERL
Coeur 'dAlene, Idaho

HENRY Ford says, "History is the bunk." Thomas Carlyle says, "History is not only the fittest study but the only study and includes all others." Both are right, but one looks forward and the other backward.

It is impossible for an American to put himself in the shoes of a Russian because behind the Russian are a thousand yaers of history which the American does not know and can understand with difficulty.

First, the Rurik dynasty ruled for seven hundred years. It became autocratic, selfish, grasping, and cruel. It came to an end with Ivan the Terrible and his son.

Second, the Romanoffs ruled Russia for over three hundred years. The first Romanoff was th eson of a priest so there was a joinder of religion and political power in one person. When the disintegration occurred orthodoxy and autocracy went down in a heap together.

The Romanoff's were able, grasping, selfish, and autocratic. Under them the Empire was extended enormously. During the 19th century the Russian Empire increased at the rate of eighty square miles per day. By 1914 it had an area of about 8,400,00 square miles —almost three times as large as the United States—with a population of about 160,000,000 people. The Czar and his family were the owners of about one-third of this great area. About 130,000 nobles owned another third, and the remainder was occupied by about 113,000,000 peasants. Only about 16-17 per cent of the people lived in the cities.

In 1914, this great Russian Empire was held together by only fifty thousand miles of railroad. The United States with only about one-third the size had about two hundred and fifty thousand miles of railroad. If a ratio is made between the area and the railway mileage, then in the United States the person farthest away from a railroad on the average had 10 miles to go while the Russian farthest away had one hundred and seventy miles.

People of the peasant class lived in very primitive fashion. Only about thirty per cent of all the people could read and write. Sixty-two per cent of the Russian soldiers were illiterate.

Of the peasants, according to the 1905 cavalry census, about thirty per cent were horseless farmers cultivating their little plots of ground with the spade, hoe, hand rake, and sickle. About thirty per cent had one horse. These, too, practically knew no machinery. Then there were twenty-two per cent having two horses.

In some parts of Russian, probably that occupied by the Swedes, people lived in isolated fashion in the country on from one hundred to three hundred acres of land in the fashion of our American farmer. But the greatest number lived in communal villages—the mir—where there was a spring of water or shallow well and where easy defense against enemies could be made. In the course of ages the sanitation of these villages often became bad. But behind the village home was a garden. A cow, a few pigs, and chickens were also to be found. . In some parts, sheep and goats predominated.

A family living in a mir never owned its land in a solid body but held

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[1]Presented at the annual meeting of the Northwest Scientific Association, December 29-30, 1931.

many little pieces within three or four miles of the village.

The Russians went into the war with the same enthusiasm that the Americans entered. They meant to get the Kaiser—devil. But the contrary happened. The Russians soon lost in killed and captured two million men—some say three million. Then came the revolution in 1917. The people wanted peace and land. The first revolution was a bourgeoise revolution with Kerensky at its head. The rich were willing to get rid of the Czar but wanted themselves to be the dominating political power. This lasted only nine months.

Out of hiding on the border of Finland came the greatest revolutionist of all time—Lenin. Together with Trotzki and others the proletarian revolution was made a reality. Then followed four years of civil war in which brother was against brother, one part of the people of a village against the other part. At the same time there were foreign enemies on eight sides. Americans and Japanese in Siberia, Czeks on the Volga, Poles around Moscow, English and French in the Crimea, Germans in the Ukraine, Finns and Esthonians and Latvians in the West. It is marvelous that the territorial integrity of Russia has been preserved as well as it has.

Then in 1921 there was an unprecedented famine over sixty million acres of ordinarily fertile land.

There is no telling how many people perished between 1914 and 1921. But Russians estimate their loss at ten to twelve million people. This meant chaos and the grand problem was to organize again a great nation.

The Russians are as proud of their revolution as we are of ours. They accomplished some of the same things. First, separation of church and state. Second, education was to be a public right—not a private privilege. But they did more. They abolished all private property in land. The land and natural resources were nationalized for the good of all. Rent no longer was to be paid to private owners. By 1921 the bankers were put out of business and all banking was done by the state. That meant no interest. Slowly the profit has been taken from merchants. All the major key industries are managed by the government.

The country is divided into seven states each having the right to secede from the federation. There are about thirty-five official languages. The state printing establishment prints books in fifty-four different languages. In all there are over one hundred languages spoken in Russia. If this self-determination idea is fully carried out, Russia will not only be a babel of languages but a business hodge podge. Nothing has made America progress so fast as one language and no political dead lines to check the free flowage of goods. The latter idea the Russians have preserved.

The autocracy of the Czar extended to the family. The father might beat up his wife and children. Now he has not the right to beat up anyone. A teacher has no right to strike a pupil. Formerly the father could dictate the marriage of his daughter. If she refused to marry as her father wished, she had to take a chance on being beaten up. Ivan the Terrible and Peter the Great beat up their sons.

Naturally, there were some marriages not founded on love To remedy this, divorce may be had for the asking on payment of a trifling fee. If there are children, the mother gets them, if there is no agreement. The mother has to furnish one-third of the children's support; the father one-third; and the state one-third. Of

course, the good of the children is considered.

At first there were many divorces, but now it would seem that the permanency of marriage is about as stable as marriage in southern California.

With millions of people perishing, there were many children thrown out on the world on their own resources. During the years of chaos their lot was pitiful. Apparently these now have been and are being cared for in public institutions, and there are no more herds of wild children.

Foreign trade is a government monopoly in Russia. In England, many branches of foreign trade are private monopolies through the organization of the Federation of British Industry. The British millers and grain dealers buy through one agency.

The basic law of the Soviets is the Roman law. Trial is had by three judges in banc all having equal power but two frequently being workers.

Lawyers are furnished to litigants by the state. They have no object in prolonging cases by endless appeals. Many former lawyers have had to learn to lay brick because there is little private property to be involved in litigation.

Doctors are supplied by the state. Our doctor received eighty dollars per month and was required to serve the public one-half of his time. There are about four thousand people to one doctor in Russia. In America there are about one thousand per doctor.

Everybody is supposed to work or starve. Women are emancipated, but are expected to work. An expectant mother is given two months off with pay before and after the birth of a child. There are no illegitimate children in Russia.

Priests, former land owners, former officials under the Czar are outcasts in society. It is their lot to live as they can. Mirabeau said during the French Revolution that he knew of only three ways to make a living—to beg, to steal, or to work for the government. That is a condition in Russia now.

In their enthusiasm for religion, in the centuries past, too many churches were built. The Soviets have left as churches only those that are needed. Worship may be carried on in any religion, but the church is not supported by tax money.

The World War was fought to make Democracy safe. Ex-Premier Nitti of Italy said that he thought that the world had been made safe for plutocracy. Whatever the truth in this regard may be, it is certain that plutocracy was made most unsafe in Russia.

The French Revolution was a bourgeoise revolution. Napoleon represented the full fruitage of that great movement. He is said to have had eighty million dollars in cash as his private property before he went to Russia. He must have been a Prince of Grafters.

Government at any age of the world has always been an extremely difficult problem. One of the worst features is graft with which old Russia was much afflicted. Russia is doing as much as possible to eliminate graft. It would be worth a man's life to acquire any considerable amount of wealth by grafting methods. He would be charged with counter-revolution or might, as Trotzki said, be treated on the spot —shot.

Pickpocketing and thievery is common now in Russia, but the Russians say that when their plan is in full swing, everybody will have all he wants and no one will steal.

We do not recognize Russia. Therefore, she may take all our patents, a fabulous wealth. She is industrializ-

ing and modernizing. She is imitating the United States in many ways. She She recognizes that we are the leading nation of the world. But she is broad and reaches out all over the world for ideas. Her telephone system is Swedish; the great Dnieprostroy Dam site is being blasted with liquid air, a German process; her medical students in Moscow are instructed by French doctors; an addition to the Czar's Yalta Palace is being built by Italian architects.

Foreign individuals and corporations in 1917 owned considerable realty and personalty in Russia. The Nobles of Sweden owned the largest part of the Baku oil fields, the Rothschilds were the second largest oil land owners. The International Harvester Company owned a two million dollar plant, and the Singer Sewing Machine Company had extensive property rights. The revolution made all such property valueless to its owners. Title passed to the Soviets without compensation to former owners. Probably compensation will never be paid. The Russians are not going to favor foreigners over their own people in the matter of the payment of damages for property seized.

The Nobles sold their Baku oil rights in 1920 to the Standard Oil Company after the Soviets had nationalized all lands. Thus the Standard Oil Company bought a bet on the defeat of the Soviets and the ultimate restoration of pre-war titles. It is difficult to estimate the force of petroleum politics in the refusal of the United States to recognize Russia.

The Russians, before the war, borrowed many millions from foreign people but none from Americans. During the war we loaned the Czar's government about $91,000,000. The Russians hate all that the Czar did, and probably will never pay any of his debts to Americans.

Then we loaned the Kerensky bourgeoise revolutionary government about $188,000,000.00 which was used in fighting the Reds and, of course, such obligations will never be paid. America butted in on the losing side just as England did in the Alabama case during our Civil war. The Russians take the same position that the United States took in the Alabama case. They ask millions of rubles damages because we conducted a military campaign against the Reds.

It may well be that the French and English, who loaned money to build the trans-Siberian railway, have just claims against the Soviets for compensation, but there certainly is no reason why the United States should pull the chestnuts out of the fire for other countries by refusing to recognize Russia.

The great key industries are, for the most part, according to American ideas. The Ford factory at Nizi Novgorod is to produce 140,000 Ford cars a year. Ford receives his costs plus fifteen per cent and sold also thirty million dollars of his autos and tractors to the Soviets. He took 50 to 60 young Russians into his factory in Detroit to teach them how to build autos.

There will be a great Caterpillar tractor factory to produce the Holt 60 to the number of forty thousand per year. This is located at Cheliabinsk in Siberia. At Stalingrad, about completed, is a factory to make 10-20 McCormick Deering tractors to the extent of fifty thousand per year. At Kharkoff a similar factory will build annually fifty thousand McCormick

Deering 15-30 tractors.

The great Dnieprostroy Dam will produce eight hundred ten thousand horse power of electricity. Only the one million horse power plant at East River in New York is greater. The Muscle Shoals Dam will produce six hundred thousand horse power of electricity.

Below the great Dnieprostroy Dam will be the greatest steel works in the world and also a great aluminum factory. The Russians recognize that we may be passing from an age of steel to an age of the light metals.

In every science one finds important names that are Russian. The great doctor Pavlov, at Leningrad, at 85 years of age is working on paranoia. A pupil of his is at the head of an experiment station on the Black Sea where monkeys are used instead of dogs as at Leningrad.

It may be said that it is a case of Science vs. Religion in Russia. Religion is a fundamental human trait and will not die out, but it is differently interpreted and directed than under the old regime. Carl Marx and Lenin are deified. One may be said to be Moses and the other Christ. A number vie with one another to be the great expounders of Marx and Lenin. The leader is Stalin.

Religion is not permitted to be publicly taught in Russia before the child has reached mental maturity—namely eighteen years of age—so that he may judge for himself.

The greatest work done today in Russia is along educational lines. It is recognized that the future depends upon the ideals and training of the young. The present age may be called the second coming of Peter the Great who had inscribed on his private seal "I belong to those who seek knowledge and are willing to learn."

This year of 1931 they propose to liquidate illiteracy of those between fifteen and forty-five years of age. There are not enough school buildings so one shift of pupils goes to school from 8 a. m. to 12 m., and a second shift comes in at 12 m. and stays until 4 p. m. Then the school is kept open for several hours in the evening for the grown-ups.

The educational department functions very broadly. Under it are the newspapers, radio, theatres, movies, and art treasures. Lunacharsky, a former aristocrat of Russia but a revolutionist, together with Krupskaya, the widow of Lenin, are at the head of the educational department.

The newspapers, radio, theatres, movies are not run for private profit. They are supposed to be managed for the good of the people. One is not bored in Russia by a lot of advertisement—honeyed to catch flies.

All things are crude in the beginning and Russia is in many ways yet very crude. Suffrage is exercised not by the Australian ballot system but by the raising of hands. Time will, no doubt, change this. Paper is a scarce article in Russia. They can not as yet afford to be as wasteful of paper as we are in our elections.

The government of Russia is as though the farmer-labor party should become dominant in the United States —only in Russia labor comes first and dominates. The government is a dictatorship of the proletariat. The

liberties enjoyed by the citizens must be inside the program of the dictators.

There are about twenty-four or twenty-five great trade unions in Russia. They total eleven to twelve millions of people. Then there are a million or more Communists. All these, with the peasants, constitute the political power of Russia. The supreme power is in about 1400 delegates who meet once a year in Moscow for two weeks.

About one hundred and fifty years ago we formed a new government on earth on principles of equality, man to man. Our government was the best that had been formed up to that time. We have made wonderful progress under it. But it is not without its faults. The Russians propose, as Lenin said "to catch up with and outstrip capitalist countries." It is their high purpose to create a better government than the world has yet experienced where human happiness and welfare are better provided for, where there shall be no exploiting of man by man, no very rich and no very poor, where selfish ambition shall be at the minimum, where the natural resources of this world shall be for all and not for favored few. Should it not be our duty to bid them God speed? Let us reserve our judgment. Let us let them develop in peace twenty, fifty, or a hundred years and then see what their attainment is.

SEVERAL PHASES OF GEOLOGY OF THE MOSES COULEE AREA

(Continued from Page 123)

Summary

The basalts in the Moses Coulee area are of upper Miocene age. They are about 1900 feet thick, and correlate with the Wenas basalts in the Ellensburg region. Underneath them, and apparently conformable, are the Douglas Canyon sediments which contain plant fossils identical with those in the Latah and Ellensburg formations. Unconformably overlying the basalts are Pleistocene and recent gravels, sands, silts and glacial drift.

The channel, referred to as Moses Coulee, cuts across several anticlinal ridges which were formed in Pliocene time. One of the folds is of mountainous size. The interpretation is that the coulee is the enlargement of an antecedent valley.

The Competitive Market and Its Relationship To Economic Theory[1]

By R. B. HEFLEBOWER
State College of Washington, Pullman, Wash.

A CLOSE analysis of the economic theory of the leading schools of thought and of individual economists discloses the fact that the differences of opinion and of conclusion arise from the differences in purpose of analysis and in the assumptions upon which the analysis is based. Differences in purpose may arise either from emphasizing the individual as opposed to social viewpoint or in emphasizing the working of economic forces under a relatively short period of time as compared to a relatively long period of time. Among the assumptions which have been important in most economic theory has been the market circumstances under which the forces determining the price of commodities and productive agencies operate. Writers usually divide markets into two types—competitive and monopolistic. A large proportion of the analysis usually deals with prices in a competitive market. The conclusions thus reached are later modified to fit monopolistic circumstances.

The most important qualifications which are necessary in the concept of the competitive market arise from the presence of collusion or conscious control of the supply by buyers. Such influence on supply may arise either from the dominant position of one large corporation, from a trade association or a community of action, or from the existence of effective trade marks. Each of these will be discussed in detail.

First, in certain fields of production, one firm occupies such a dominant position that it practically determines prices. The percentage of total supply which is necessary to control the price depends upon the commodity and the degree of price control desired. In some case, it may be necessary to control over three-fourths of the total output, while in other cases, a considerable degree of price control can be brought about by one corporation which controls considerably less than one-half of total production. The existence of such dominant corporations in America has been made possible by the Supreme Court's interpretation of the Anti-Trust Laws in the case of the United States Steel Corporation, in which the court ruled that the law was violated only in case at least 50 per cent of the total production was controlled by one producer.[2] At that time, the United States Steel Corporation controlled 45 per cent of the total production of steel in the United States. Hence, under the court's ruling, that company was not violating the Anti-Trust Laws. That the United States Steel Corporation was effectively controlling prices is supported by the fact that the price of steel rails did not change between 1902 and 1916, whereas the price had oscillated considerably previous to 1902.[3]

In the case of agricultural cooperatives, the usual Anti-Trust Laws are largely inoperative. The Capper-Volstead Act of 1922 specifically excluded

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[1]Presented at the annual meeting of the Northwest Scientific Association, December 29-30, 1930.

[2]U. S. vs. U. S. Steel Corp., 251 U. S. (1920).

[3]Brief submitted by the government in the Steel Case

agricultural cooperatives from the working of the Sherman and Clayton Anti-Trust Laws. Therefore, it is perfectly legal for such a cooperative to control 100 per cent of its particular commodity. To be sure, the Secretary of Agriculture is to interfere when a cooperative exercises its powers adversely to the welfare of consumers. Nevertheless, this law legalizes a certain type of monopoly.

The second type of interference by conscious control of the price situation arises from the activity of trade associations and communities of action. The conditions giving rise to associations interested in influencing prices are well explained by Professors Seager and Gulick as follows:

> "Moreover, the development in more and more industries of extremely expensive tools of production, involving the burden of a high percentage of fixed charges which each manufacturer wishes to distribute over as large an output as possible, has accentuated the tendency inherent in all competition to become cutthroat competition. When the railroad managements realized what cutthroat competition meant they organized to stop it, a measure which at first met with legislative disapproval, but which now, after almost forty years, stands endorsed by Congress. Numerous line of idustry have been for some time more or less in the same predicament faced by the railroads. . . Agreements to restrict production or fix prices are illegal as well as exceedingly difficult to maintain. What was needed was some method of informing each unit of the business or industry of the exact situation in that line with the hope that the intelligence of even the most incompetent member of the group would be equal to the task of interpreting and applying the information supplied in such a way as to prevent overproduction and cutthroat competition. And, as noted in the introductory sections of this chapter, the 'open-price' or 'open-competition' plan was formulated to meet this need."[4]

Just how many trade associations at the present are effectively interfering with the supply or price of various products is difficult to ascertain.[5] As much of the activity of such associations in this regard would be illegal, they are very careful to prevent giving direct evidence of their activities. The fact that trade associations exist and effectively influence prices and supply in various fields of economic endeavor is well known indirectly. Concrete evidence of this fact is supported by such considerations as the following: First, the dealers or producers of certain goods quote standardized prices from which they do not depart, except under unusual circumstances. Illustrations of this are frequent in the building materials field. The second evidence is the failure of prices of these commodities to vary with changes in the supply or demand situation for these particular commodities. When business depression arrives and the demand declines, price declines would be expected; however, these declines are slow in occurring due apparently to a tendency to peg prices. The third evidence is the failure of individual producers to respond to those changes in the prices and demand situation which do occur in a manner such as

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[4]Seager, H. R., and C. A. Gulick, Jr., "Trust and Corporation Problems (New York, 1929), pp. 317, 318.

[5]The number of trade associations has been variously estimated from 1,000 to 5,000. However, not all of these associations are interested in prices necessarily.

would be expected to hold true in a competitive industry. Theorists hold that in an industry which has a high proportion of fixed costs, producers tend to continue operations at capacity even in times of decline in demand for the products of the industry as a whole. There are very few industries in which this actually occurs today, due, apparently, either to organized opposition by the producers whereby they agree to curtail operations or to fear of spoiling the market.

The legal position of such associations should be discussed further. The Webb-Pomerene Act allows combinations in export trade which would be illegal in domestic trade. Such combinations, by fixing the export price, can greatly influence the domestic price. Thus, the Copper Exporters' Association fixes the export price of copper, which is considered in the business field as "the" price of copper. The legal status of exchange of price information and similar activities which may have a bearing on prices by members of a trade association is not clear. The decisions in the case of the American Hardwood Manufacturers' Association in 1921,[6] and in the case of the Linseed Crushers' Council in 1923[7] seriously limited the activities of such associations. More liberal interpretations of the Anti-Trust Laws in the cases of the Maple Flooring Association[8] and the Cement Manufacturers' Protective Association[9] in 1925, again expanded the scope of activities of such associations under the law. Considering the uncertain legal status of price activities, it is highly probable that much of the activities actually influencing prices are carried on in secret.

The future legal status of such associations is a matter of intelligent surmise. The business necessity of price activities has had much influence on court decisions. In the Maple Flooring case the court applied the rule of "necessary tendency" or "business expediency" previously laid down in the Steel Corporation case. Mere existence of combination or power to influence prices is not sufficient to prove the organization illegal. "The sole question . . . is whether the combination of defendants in their existing association as actually conducted by them has a necessary tendency to cause direct and undue restraint of competition in commerce falling within the condemnation of the Act."[10]

Besides more liberal views by the court, a change in public opinion as reflected in legislation is entirely possible. Seager and Gulick, as quoted above, point out the analogy in the change in public attitude toward railroad consolidation. Concrete evidence is presented in the government's attempt to stabilize the crude oil industry. More revolutionary still are the activities of the Farm Board under the Agricultural Marketing Act of 1929, which may be interpreted largely as a governmentally promoted trade association for agriculture. This has been more fully discussed by the present writer elsewhere.[11]

Organizations to influence prices exist not only in the markets for finished commodities, but also in the markets for the factors of production. Strong labor unions have within their power the temporary control of their particular kinds of labor. The whole supply may be withdrawn from employment or put into employment, through agreement of the laborers

[6]257 U. S. 402 (1921).
[7]262 U. S. 380 (1923).
[8]268 U. S. 567 (1925).
[9]268 U. S. 588 (1925).
[10]268 U. S. 578 (1925).
[11]Heflebower, R. B., "Price Stabilization Under the Farm Board", Journal of Farm Economics, October, 1930.

themselves. As a counterpart to labor unions are employers' associations of similar size and strength. The Federal Reserve system, in one aspect, is an organization for influencing the price of credit.

The third type of conscious interference with the free working of economic forces arises from trade-names and trade-marks. For present purposes, these terms will be used synonymously. A trade-mark receives its value from the fact that buyers come to associate this identification mark with a certain quality and service. Buyers arrive at this attitude through the influence of advertising and salesmanship, and through continued satisfaction with the quality of the product and the service.

The general opinion is that advertising forms an effective tool of competition. However, as a factor affecting prices, advertising should be looked upon as a means whereby the advertiser hopes to escape a certain amount of price competition. The advertiser expects that consumers will come to buy by brand and if he can build up a large clientele of buyers who prefer his product in preference to that of other producers he obtains a certain power over price and supply which will enable him to increase his profits. Within narrow limits, the advertiser can fix the price of his brand without reference to the prices charged by competitors. In many cases, the advantageous position of the advertiser does not arise from being able to exact a higher price, but from being able to sell a very large amount at the usual price. Without the protection of a brand, to attempt to sell such an amount as this in a general market would probably lead to severe price competition.

Effects of Interference With Competitive Forces

The existence of interference in the working of competitive forces by the agencies of corporations dominant in their particular fields, trade associations, and trade-marks has been explained. The relation of these interfering factors to the concept of the competitive market must now be explained.

In this part of the analysis it is more logical to discuss trade-marks first. The success of one trade-mark in marketing a particular product encourages competing companies to adopt like tactics. The latter attempt to invade the "private market" or clientele built up by the former. The former must resist, which increases selling costs in proportion to volume. Soon all, or nearly all, of the producers in this field must push their respective trade-marks. Increased advertising yields diminishing returns. No producer dares to discontinue advertising, for his competitors will see to it that consumers soon forget him. Yet no producer can obtain a permanent advantage. To be sure, one firm's advertising will prove more effective for a time, yielding larger sales and profits. Such success only spurs rivals to still greater efforts in the marketing field, although weak firms may fall by the wayside. If so, advertising is proving an effective tool in expanding the size of the producing unit.

Effective trade-marking does allow a temporary interference with prices and volume as they would be determined in the absence of trade-marking. However, there is no proof at present that such devices allow the producers to force prices above their competitive equilibrium permanently. Prices tend to reach the same point, in the long-run, whether trade-marks are used or

not. Trade-marking only introduces new forces which bring prices to this point.

Even the position of a large and powerful corporation which dominates its field is not impregnable. As soon as it so influences prices that it obtains monopoly-profits, either new or latent competition springs up or the public interferes. Professor Eliot Jones, in his analysis of the activities of the American Sugar Refining Company, points out this fact clearly. Whenever this monopoly proceeded to raise prices above a competitive level, new competition sprang up. The cost of keeping down such competition was so very high, whereas the American Sugar Refining Company had controlled 98 per cent of the country's output of cane sugar in 1892, by 1910 only 42 per cent of the total output of sugar was produced by this company.[12] Finally the monopoly was dissolved under the Anti-Trust Laws. Within the last few years the dominant position of the United States Steel Corporation has become to be threatened by the growing power of the Republic and Bethlehem corporations.

Where the control of a relatively large part of the total production is condoned by law, a monopoly may remain strong for a relatively long period of time. Such has been the record of the United States Steel Corporation. This conclusion must be qualified where the production can be quickly increased by other producers. Monopolistic activities of agricultural cooperatives have always proved suicidal, since they cannot prevent the usual response of production to favorable prices. The more excessive monopoly powers exercised, the more quickly will new production spring forth. All in all, monopoly power tends to be temporary; prices tending toward cost over a long period of time.

Even with legal approval of a considerable degree of price activity by trade associations, the power of such associations over prices is quite limited. It is true that prices might be raised for a time, but not permanently. When prices are held above cost, the temptation is great to individual members to secretly cut prices and obtain large volume. New producers, outside the association, will spring up. Non-members will expand. Even such an apparently strong organization as the International Steel Cartel has its vicissitudes. The increasing difficulty of keeping Germany within her quota, competition from non-members, and the world-wide depression of 1930 has made the future of the Cartel dubious. The organization meeting in September, 1930, adjourned to meet in the following December, at which time the question of whether to continue or disband was to be decided. The Copper Exporters' Association's attempts to peg the price of copper in 1929 and 1930, in face of overproduction, failed. Trade associations cannot prevent the operation of these tendencies of prices toward cost, over a long period of time.

A new field of group activity is that of reducing the ill effects of competition without attempting to interfere with fundamental competitive forces. Unrestricted competition works through the instrumentalities of price wars, excessive selling costs, and unforseen losses, even to those whose business is economically necessary. The risk of business enterprise is increased. Economic forces sometimes work slowly, with much friction and injustice. To reach competitive equilibria without the costs and time re-

[12]Jones, Eliot, "The Trust Problem in the United States (New York, 1922), Chapter VI.

quired by competition offers a new field for trade association activities.

That the possibility of such organized activity has been noted is evidenced by many facts. The analogy drawn by Seager and Gulick (quoted above) between the past problems of the railroads and the present problems of industry supports this view. Industry has come to look upon association as means of preventing price wars. Even some excessive selling costs may be eliminated. But no attempt will be made to hold prices high so as to encourage new competition. The activities of the Farm Board, both in regard to short-time prices and in regard to year to year prices, are aimed to control price fluctuations around a competitive equilibrium.[13]

In so far as trade associations adopt such a policy as this, they face the serious problem of objectively locating the equilibrium price. In some cases, involved statistical analysis will largely solve this problem. In other cases, the decision will need to rest upon the judgment of the leaders of the industry.

Out of this latter function of group organizations, a new concept of competition is evolved. Prices are expected to reach the same point as though no organized control existed. The difference comes in the forces whereby prices reach this point. Conscious control is to be substituted for the unregulated rivalry of sellers, primarily, and to a certain extent, that of buyers.

Conclusions

I. Individualizing of finished goods through branding gives limited and temporary price control to the producer. In the long run, the prices of such goods cannot be held above a competitive equilibrium.

II. Dominant corporations and trade associations can, to varying degrees, hold prices out of line with a competitive point, in the short run. Even here, actual prices tend toward a competitive equilibrium in the long run. The time required to reach equilibrium varies.

III. There is strong evidence of a new field of conscious price control, namely, that of holding prices at approximately their competitive equilibrium. Out of this situation grows a new interpretatoin of a competitive market, that of groups holding prices at a level corresponding to that of the usual competitive market.

[13]See Heflebower, R. B., Op. Cit.

PROGRAM

of the

Ninth Annual Meeting

of the

Northwest Scientific Association

December 28-29, 1932

Davenport Hotel Spokane, Washington

Registration Desk
Mezzanine Floor, Davenport Hotel

PRESIDENT

Ivan C. Crawford, University of Idaho, Moscow, Idaho

VICE-PRESIDENT

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E. F. Gaines, State College of Washington, Pullman, Washington
G. D. Shallenberger, State University, Missoula, Montana

TRUSTEES

Francis A. Thomson, State School of Mines, Butte, Montana
L. K. Armstrong, Spokane, Washington
Thomas Large, Lewis and Clark High School, Spokane, Washington

LOCAL COMMITTEE

Ellis B. Harris, Chairman; Thomas Large, L. K. Armstrong, C. R. Stillinger, L. W. Salts, H. N. Putnam, A. D. Butler, S. E. Lambert.

INSTITUTIONAL MEMBERS
of the
NORTHWEST SCIENTIFIC ASSOCIATION

University of Idaho, Moscow, Idaho
State College of Washington, Pullman, Washington
State School of Mines, Butte, Montana
State Normal School
Bellingham, Washington
State Normal School
Ellensburg, Washington
State Normal School, Cheney, Washington

REDUCED RATES FOR MEETING

Members of the Association will be able to avail themselves of the round trip fare and a third rate now in effect, with limit of ten days. Under this plan the convention certificates used at past meetings will not be necessary. Members should take advantage of any special rates that may be offered to the public if they are available during the days of the meeting.

MEMBERSHIP

Membership in the Association is open to any one paying the annual dues of one dollar. Members receive, without additional cost, the issues of Northwest Science, the official publication of the Association.

HEADQUARTERS

The Davenport Hotel will be the official headquarters of the Association during the meeting and all general and section meetings will be held in the hotel.

REGISTRATION

The registration desk will be found on the mezzanine floor of the Davenport Hotel. All old members should register and receive their official badge for the meeting. At the same time they should see that their dues are paid. New members should fill out a membership card and pay the annual dues.

ANNUAL DINNER
Luncheon—Breakfast

The annual dinner will be held at 6:30 P.M. on Wednesday, Decmber 28, in the Elizabethan Rooms. Reservation should be

made at the time of registration. Price $1.25. Members and guests are invited to attend. Ernest O. Holland, retiring President of the Association, will give the address of the evening.

There will be a joint luncheon on Wednesday, December 28, at 12 o'clock in the Elizabethan Rooms, the Associated Engineers of Spokane and the Northwest Scientific Association participating. Price sixty-five cents. W. A. Rockie, U. S. Bureau of Soils, will speak. Subject: "Some Important Effects of the Summer Fallow System of Farming on Soil Erosion in the Pacific Northwest".

There will be a Sigma Xi breakfast for members and friends on Thursday morning, December 29, at 8 o'clock in the East Banquet Hall. Reservations should be made at time of registration. Price seventy-five cents.

SCHEDULE OF MEETINGS

Wednesday, December 28

9:00 A.M.—Registration. Mezzanine Floor

10:00 A.M.—General Session, Elizabethan Rooms A, B, C.

12:00 Noon—Joint Luncheon with the Associated Engineers of Spokane. Elizabethan Rooms.

1:30 P.M.—Sectional Meetings.
Botany-Zoology. Elizabethan Rooms B, C.
Chemistry-Physics. Elizabethan Rooms D, E.
Education. Room 200.
Engineering. Elizabethan Room A.
Forestry. Mandarin Room.
Geology-Geography. East Banquet Hall.
Social Science. Hall of the Doges.

6:30 P.M.—Annual Dinner. Elizabethan Rooms.

Thursday, December 29

9:00 A.M.—Annual Business Meeting of Association. Elizabethan Rooms A, B, C.

10:00 A.M.—Sectional Meetings.
Education. Room 200.
Geology-Geography. East Banquet Hall.
Social Science. Hall of the Doges.

1:30 P.M.—Sectional Meetings.
Botany-Zoology. Elizabethan Rooms B, C.
Chemistry-Physics. Elizamethan Rooms D, E.
Education. Room 200.
Engineering. Elizabethan Room A.
Forestry. Mandarin Room.
Geology-Geography. East Banquet Hall.

GENERAL SESSIONS

Wednesday, December 28

10:00 A.M.—Elizabethan Rooms A, B, C.

1. "Tick Borne Diseases of the Rocky Mountain Region," R. R. Parker, U. S. Public Health Service, Hamilton, Montana.
2. "A Deep Sea Fishery," W. F. Thompson, University of Washington, Seattle, Washington.

12:00 Noon—Elizabethan Rooms. Joint Luncheon with Associated Engineers.
Address: "Some Important Effects of the Summer Fallow System of Farming on Soil Erosion in the Pacific Northwest," W. A. Rockie, U. S. Bureau of Chemistry and Soils, Pullman, Washington. Introduction of the speaker by L. K. Armstrong, Spokane, Washington, President, Washington Natural Resources Association.

6:30 P.M.—Annual Dinner. Elizabethan Rooms.
President Ivan C. Crawford, Chairman.
Address of Retiring President Ernest O. Holland, State College of Washington, Pullman, Washington. Subject: "Science and its Contribution to Civilization."

Thursday, December 29

9:00 A.M.—Elizabethan Rooms A, B, C.
President Ivan C. Crawford, Chairman.
Reports of officers and committees. Discussion and vote on proposed amendment to constitution. Election of officers.

7:30 P.M.—Hall of the Doges.
Meeting of the Northern Rocky Mountain Section, Society of American Foresters.

BOTANY-ZOOLOGY

H. B. Stough, University of Idaho, Moscow, Idaho, Chairman.
R. A. Diettert, University of Idaho, Moscow, Idaho, Secretary.

Wednesday, December 28

1:30 P.M.—Elizabethan Rooms B, C.

1. The Nutritional Role of the Intestinal Fauna and Flora of Termopsis—R. E. Hungate, Stanford University, Palo Alto, California. 20 minutes.
2. Some Factors Controlling the Distribution of Pinus Contorts—Elbert M. Long, University of Idaho, Moscow, Idaho. 30 minutes.

3. Some Ecological Aspects of Lichens in Succession—Robert Darrow, University of Idaho, Moscow, Idaho. 15 minutes.
4. Notes on Some Fungi of the Northwest—R. A. Diettert, University of Idaho, Moscow, Idaho. 15 minutes.
5. Predetermination as a Factor in Anthokinetics—A. L. Hafenrichter, State College of Washington, Pullman, Washington. 15 minutes.

Thursday, December 29

1:30 P.M.—Elizabethan Rooms B, C.

1. Business Session.
2. The Value of the Hybrid Wheats Produced by Washington State College—E. F. Gaines, State College of Washington, Pullman, Washington. 15 minutes.
3. The Question of Cell Division and Its Relation to Biology—H. B. Stough, University of Idaho, Moscow, Idaho. 25 minutes.
4. Ethylene Gas Affecting Plant Growth—C. A. Michaels, University of Idaho, Moscow, Idaho. 20 minutes.
5. Methods of Tissue Culture—Virginia Peck, University of Idaho, Moscow, Idaho. 15 minutes.
6. Studies on the Function of the Pycniospore of the White Pine Blister Rust Fungus and Possibilities of Its Being a Means of Control—Royale K. Pierson, University of Idaho, Moscow, Idaho. 25 minutes.
7. Genetics of Resistance to Four Physiologic Forms of Bunt in Two Winter Wheat Crosses—A. M. Schlehuber, State College of Washington, Pullman, Washington. 15 minutes.
8. The Life History of a Nematode Parasitic in the Stomach of Turtles—Leslie Hedrik, Whitworth College, Spokane, Washington.

CHEMISTRY-PHYSICS

G. L. Luke, University of Idaho, Moscow, Idaho, Chairman

Alonzo W. Martin, University of Idaho, Moscow, Idaho, Secretary

Wednesday, December 28

1:30 P.M.—Elizabethan Rooms D, E.

1. The Determination of Formic and Acetic Acids in the Presence of Aqueous Sulfuric Acid by a Modification of the Ducleaux Method—F. O. Gibson and W. E. Brandt, State College of Washington, Pullman, Washington. 15 minutes.
2. Some Factors Pertaining to the Electrodeposition of Manganese from Aqueous Solutions—H. H. Oaks and W. E. Brandt, State College of Washington, Pullman, Washington. 15 minutes.
3. The Electrochemical Reduction of 2-4 Dinitro-ortho-cresol. Second Progress Report—H. B. Linfold and W. E. Brandt, State College of Washington, Pullman, Washington. 10 minutes.
4. Adsorption of KCl by Finely Divided Silver Metal; a Check on Some Work Previously Reported by H. V. Euler and A. H. Hedelius—Otto Turinsky, University of Idaho, Moscow, Idaho. 10 minutes.
5. A Simplified Qualititative Scheme—R. W. Gelbach, State College of Washington, Pullman, Washington. 15 minutes.
6. The Temperature Coefficient of the Interfacial Tension at Some Oil-Mercury Interfaces—Fritz Hedman and J. L. Culbertson, State College of Washington, Pullman, Washington. 10 minutes.
7. Preliminary Studies in Chemistry Aptitude—C. C. Todd, State College of Washington, Pullman, Washington. 20 minutes.

Thursday, December 29

1:30 P.M.—Elizabethan Rooms D, E.

1. Business seccion.
2. Activity Coefficients of Potassium Iodide—R. W. Gelbach, State College of Washington, Pullman, Washington. 15 minutes.
3. Chemical By-Products—J. L. St. John—State College of Washington, Pullman, Washington. 10 minutes.
4. A New Training Device for Free Fall Apparatus—K. E. Fitzsimmons, State College of Washington, Pullman, Washington. 15 minutes.
5. Seasonal Variation in Pacific Coast Cranberries—Janice Conklin, Harvey Murer and R. P. Cope, State College of Washington, Pullman, Washington. 10 minutes.
6. Electrochemical Behavior of Germanium—J. Ivan Hall and A. E. Koenig, State School of Mines, Butte, Montana. 20 minutes.
7. Brownian Movement—Ralph Schlichtig, State College of Washington, Pullman, Washington. 15 minutes.
8. Chemistry and Colds—Harry L. Cole, State College of Washington, Pullman, Washington. 10 minutes.

EDUCATION

C. I. Erickson, State College of Washington, Pullman, Washington, Chairman
Clarence C. Cooil, Cheney, Washington, Secretary

Wednesday, December 28

1:30 P.M.—Room 200.

1. Scientific Aspects of Education—C. M. Frasier, State Normal School, Cheney, Washington. 30 minutes.
   H. P. Aldrich, Reardan, Washington. 20 minutes.
2. Study of the Ability Level to Which College Teaching is Directed—R. F. Hawk, State Normal School, Cheney, Washington. 30 minutes.

Thursday, December 29

10:00 A.M.—Room 200.

1. Educational Preferences of Students in Certain Washington High Schools—E. C. Johnson, State College of Washington, Pullman, Washington 12 minutes.
2. Locating Sources of Error in the Reasoning of Arithmetic—C. W. Stone, State College of Washington, Pullman, Washington. 15 minutes.
3. Personality Development of the Superior Student—R. F. Hawk, State Normal School, Cheney, Washington. 30 minutes.

1:30 P.M.—Room 200.

1. Business session.
2. The Growth of Infant Adaptive Behavior in a Simple Tool Situation; an Experimental Study—Helen M. Richardson, State College of Washington, Pullman, Washington. 15 minutes.
3. Some Concepts of Instinct—J. P. Ingle, State College of Washington, Pullman, Washington. 20 minutes

ENGINEERING

G. E. Thornton, State College of Washington, Pullman, Washington, Chairman

Wednesday, December 28

1:30 P.M.—Elizabethan Room A.

1. Crazing on Concrete—Jesse E. Buchanan and William Schroeder, University of Idaho, Moscow, Idaho. 30 minutes.
2. Old Missions of the Inland Empire—Stanley Smith, State College of Washington, Pullman, Washington. 30 minutes.
3. Relation of Endurance Limit in Fatigue to Elastic Limit in Tension for Steel—Theodore Mann, State College of Washington, Pullman, Washington. 30 minutes.

Thursday, December 29

1:30 P.M.—Elizabethan Room A.

1. Business session.
2. Air Conditioning, a New Industry in the Making—H. R. Bender, Washington Water Power Company, Spokane, Washington. 60 minutes.
2. Electric Lighting—Harry F. Lickey, State College of Washington, Pullman, Washington. 30 minutes.

FORESTRY

S. N. Wyckoff, U. S. Blister Rust Office, Spokane, Washington, Chairman

Wednesday, December 28

1:30 P.M.—Mandarian Room.

Forest Research Needs of the Inland Empire

1. Silviculture.
   a. Progress of Research—R. H. Weidman, Northern Rocky Mountain Experiment Station, Missoula, Montana. 15 minutes.
   b. Research Needs for the Future—F. G. Miller, University of Idaho, Moscow, Idaho. 15 minutes.
2. Fire Protection.
   a. Progress of Research—H. T. Gisborne, Northern Rocky Mountain Experiment Station, Missoula, Montana. 15 minutes.
   b. Research Needs for the Future—T. C. Spaulding, State University, Missoula, Montana. 15 minutes.
3. Tree Diseases.
   a. Progress of Research—E. E. Hubert, University of Idaho, Moscow, Idaho. 15 minutes.
   b. Research Needs for the Future—C. W. Waters, State University, Missoula, Montana. 15 minutes.
4. Insects.
   a. Progress of Research—J. C. Evenden, U. S. Bureau of Entomology, Coeur d'Alene, Idaho. 15 minutes.
   b. Research Needs for the Future—Elers Koch, U. S. Forest Service, Missoula, Montana. 15 minutes.

Thursday, December 29

1:30 P.M.—Mandarin Room.

Forest Research Needs of the Inland Empire (continued)

1. Business session.
2. Range Management.
   a. Progress of Research—E. H. Steffen, State College of Washington, Pullman, Washington. 15 minutes.
   b. Research Needs for the Future—Lyle F. Watts, Northern Rocky Mountain Experiment Station, Missoula, Montana. 15 minutes.
3. Utilization.
   a. Progress of Research—J. H. Ramskill, State University, Missoula, Montana. 15 minutes.
   b. Research Needs for the Future—E. C. Jahn, University of Idaho, Moscow, Idaho. 15 minutes.
4. Economics.
   a. Progress of Research—M. I. Bradner, U. S. Forest Service, Missoula, Montana. 15 minutes.
   b. Research Needs for the Future—M. H. Wolff, U. S. Forest Service, Missoula, Montana. 15 minutes.

GEOLOGY-GEOGRAPHY

John W. Finch, University of Idaho, Moscow, Idaho, Chairman

Andrew V. Corry, State School of Mines, Butte, Montana, Secretary

Wednesday, December 28

1:30 P.M.—East Banquet Hall.

The Batholiths of the Northwest
A Symposium

1. Idaho's Batholith and Montana's Mountains—Charles H. Clapp, State University, Missoula, Montana. 20 minutes.
2. Batholiths of Oregon—E. T. Hodge, University of Oregon, Eugene, Oregon. 20 minutes.
3. A Batholith in the Northern Cascades—Harold E. Culver, State College of Washington, Pullman, Washington. 15 minutes.
4. Structure and Genesis of the Cassia Batholith, Idaho—Alfred L. Anderson, University of Idaho, Moscow, Idaho. 15 minutes.
5. The Chelan Batholiths, Washington—A. C. Waters, Stanford University, Palo Alto, California.

Thursday, December 29

10:00 A.M.—East Banquet Hall.

Batholiths of the Northwest (continued)

1. Petrography of the Idaho Batholith in the Boise Basin—Alfred L. Anderson and C. Alfred Rasor, University of Idaho, Moscow, Idaho. 15 minutes.
2. The Idaho Batholith—Clyde P. Ross.
3. Granitic Rocks of the Pearl District, Idaho—Thos. H. Hite, University of Idaho, Moscow, Idaho. 5 minutes.
4. Granite Creek Batholith and Eruptive Dykes and Sills, Lincoln County, Montana—J. H. Eby, Spokane, Washington. 15 minutes.
5. Relation of Batholiths to Major Structure in the Southern Montana Rockies —Eugene S. Perry, State School of Mines, Butte, Montana. 20 minutes.
6. A Summary of Certain Unpublished Conclusions of Geologists now Working in the Rocky Mountains and in the Pacific Coast Province—John W. Finch, University of Idaho, Moscow, Idaho. 15 minutes.

1:30 P.M.—East Banquet Hall.

1. Business session.
2. Stagnation of the Okanogan Lobe of the Cordilleran Ice Sheet and Resulting Physiographic Effects—Otis W. Freeman, State Normal School, Cheney, Washington. 25 minutes.
3. A Comparison of Fine Placer and Vein Gold—Thos. H. Hite, University of Idaho, Moscow, Idaho. 10 minutes.
4. Some Points on the Columbia—E. M. Tardy, Inchelium, Washington. 10 minutes.
5. Paleozoic Stratigraphy in Northwestern Montana—C. F. Deiss, State University, Missoula, Montana. 25 minutes.
6. An Ancient Glacial Formation in Idaho —Alfred L. Anderson, University of Idaho, Moscow, Idaho. 15 minutes.

MEDICINE-SURGERY

David Hartin, Spokane, Washington, Chairman

William E. Grieve, Spokane, Washington, Secretary

Wednesday, December 28

3:30 P.M.—Elizabethan Rooms.

1. Business session.

2. Efforts of Tonsillectomy on Antitoxic Immunity to Diphtheria—W. A. Buice, State College of Washington, Pullman, Washington. 20 minutes.
3. Results of Eight Years' Use of the Rocky Mountain Spotted Fever Vaccine—R. R. Parker, U. S. Public Health Service, Hamilton, Montana. 30 minutes.
4. The Child and its Appetite—Clarence L. Lyon, Spokane, Washington. 20 minutes.

SOCIAL SCIENCE

T. S. Kerr, University of Idaho, Chairman
Claudius O. Johnson, State College of Washington, Pullman, Washington, Secretary

Wednesday, December 28

1:30 P.M.—Hall of the Doges.

1. The First Settlers' Memorial From the Oregon Country; an Interpretative Study of a Governmental Document—C. J. Brosnan, University of Idaho, Moscow, Idaho. 30 minutes.
2. Localization in the Iron and Steel Industry—Victor Roterus, State College of Washington, Pullman, Washington. 30 minutes.
3. Historical vs. Natural Boundaries in the Northwest—C. S. Kingston, State Normal School, Cheney, Washington. 30 minutes.

Thursday, December 29

10:00 P.M.—Hall of the Doges.

1. Business session.
2. Method and its Relation to Sociological Investigation—H. M. Hayward, State College of Wahsington, Pullman, Washington. 30 minutes.
3. The Course in World History—Frederic C. Church, University of Idaho, Moscow, Idaho. 30 minutes.
4. Salvaging the Problem Student—F. J. Bowman, State College of Washington, Pullman, Washington. 30 minutes.

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THE SECRETARY, BROOKLYN BOTANIC GARDEN

1000 Washington Ave., Brooklyn, N. Y., U. S. A.

MOSCOW PUBLISHING CO.
Printers
MOSCOW, IDAHO

NORTHWEST SCIENCE

NATIONAL HISTORY

MARCH
1933
Vol. VII Number 1

73
N87

Published by
The
Northwest Scientific Association
Single Copy Thirty-five Cents

NORTHWEST SCIENCE

A scientific journal published quarterly by the Northwest Scientific Association and devoted to the dissemination and promulgation of scientific effort in the Pacific Northwest

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NORTHWEST SCIENCE

Entered as second class matter April 5, 1927, at the Post-Office at Cheney, Washington. Office of Publication, Cheney, Wash.

Published quarterly at a subscription price of $1.00 per year, which includes the membership dues of the Association. Non members $1.00 per year. Vols. I (1927), II (1928), III (1929), IV (1930), V (1931), complete, each $1.25.

Reprints of articles appearing in regular issues will be furnished to the author at the following rates, *provided they are ordered prior to the time of going to press.*

Pages	2	4	8	12
100 copies without cover	$2.50	3.00	5.45	5.95
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300 copies with cover		6.25	8.75	11.75

Printing of plates extra, at actual cost

NORTHWEST SCIENCE

VOL. VII MARCH, 1933 No. 1

The Association is not responsible, as a body, for the facts and opinions advanced in the papers published by it.

EDITORIAL

ONE of the foremost researchers of our country, a chemist, in discussing the status of scientific workers and professional teachers, made the statement that "teaching is our most important business; for a failure to pass on for a single generation the painfully accumulated knowledge of the race would return the world to barbarism".

With our eyes often short-focused upon the research problems which absorb our interest as well as our time and energy we can easily lose sight of this important phase of our work. And with the ever increasing reversals of standards and relative values which the world is facing today, we, who have elected to become lantern-bearers, to delve into the recesses of fact and to pass these facts on for the use and upbuilding of mankind, must pause to view the road we are traveling. The continued and ever increasing value of scientific effort to a people struggling to reconstruct a shattered economic framework depends largely upon our teachings. The history of nations bears witness to the shifting and often fickle interest in things scientific, a fact which frequently can be traced to the inadequate absorption by the people of the value of research activities. It was not so long ago that a republic guillotined the chemist, Lavoisier, because the people felt they had no need of chemists. A more recent revolution almost obliterated scientific endeavor in a country which is now feverishly attempting to reestablish an adequate research organization. What has happened once may happen again. We are faced with disturbed economic conditions, with the violent urge to change things regardless of rime or reason and we must exert ourselves to make science understandable to others; not in the selfish interest alone, that of making a living, but in the broader interest of holding steadfast to the territory already gained in scientific progress.

After an investment of money and years of study the teacher or scientist finds that "carrying a lantern is often less remunerative than carrying a hod" and that salaries like glaciers move forward slowly but seldom leave a terminal moraine to protect him and his family against want. However, a scientist's wealth is not of fine gold, it is inalienable and tax exempt; and so his interest, unhampered by material bonds, is free to rise above economic stress and may continue to strive for enlightenment through discovery.

Vocational Preferences of Students in Certain Washington High Schools[1]

by

EDWARD C. JOHNSON

State College of Washington

THE vocational preferences of high school students are of much importance to the individuals concerned. They have a bearing on the educational policies of the institutions of higher learning. They will have considerable influence on the future leadership of the state and therefore are of interest to every educator. To give additional light on this subject the office of the Dean of Agriculture of the State College of Washington in March, 1932, solicited the cooperation of the high school principals of the state in a study of the vocational preferences of high school students. This was freely given and acknowledgment is here made of the help and of the care with which this part of the work was done.

The high school principals were asked to set aside one assembly period for this study. They were requested to put on the board a set of questions designed to bring out the preference of each cooperating student, and to have the students answer these questions by number on slips of paper to be assembled at the end of the period and then forwarded to the Office of the Dean of Agriculture. It was requested also that the students were not to be told of the study until the time it was made. Of the 274 accredited high schools in Washington to which the questionnaire was sent, 135, or almost one-half, gave effective cooperation. This was sufficient for a thoroughly representative cross-section of the students in the high schools in the larger cities, in the smaller cities, and in the country towns and communities.

The questions given to the students included the following: Do you live in the town or in the country? What do you purpose to do or what vocation do you intend to follow after you have completed your education? Do not put down "Expect to go to college." What is desired is what you intend to do for a living or what you have in mind as your future occupation. If you have noting definite in mind, do not answer the question. Also what is the principal reason or reasons which have caused you to prefer the occupation mentioned?

Other questions, some 14 in all, were included in this questionnaire, but in this short paper only replies to two or three of the more important are summarized. Reports from a comparatively small number of high schools and only two groups of students are used in this summary, namely, reports from farm boys who are enrolled in high school in cities and towns of between 2000 and 5000 in population, including Sunnyside, Cle Elum, Dayton, Omak, Sedro-Woolley, Pullman, Mount Vernon, Auburn, Ellensburg, and Chehalis; and town boys in cities having a population of between 21,723 and 365,583, including Aberdeen, Everett, Spokane (Lewis and Clarke) and Seattle (West Seattle High).

A considerable proportion of the country boys in the town high schools

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[1]Presented at the annual meeting of the Northwest Scientific Association, December 28-29, 1932, Spokane, Washington. Published as Scientific Paper No. 254, Sollege of Agriculture and Experiment Station, State College of Washington.

have an interest in the extractive industries, primarily agriculture and forestry. This would be expected since they see these occupations every day and live the life of those engaged in them. They know practically nothing about mining and, therefore, are not interested in it. They know very little about commercial fishing, consequently this is not included in their vocational preference.

Approximately 38 per cent of the farm boys in the town high schools who expressed their preferences, were interested in agriculture or forestry as a life's vocation, 30 per cent in the former and 8 per cent in the latter. The variation between the boys of different ages or rather of different grades or classes, was not very great, 30 per cent of the freshmen, 44 per cent of the sophomores, 34 per cent of the juniors, and 39 per cent of the seniors being interested in these vocations. A smaller percentage of the city boys are interested in the extractive industries; only 6.6 per cent indicating a preference for them as compared with 38 per cent among the country boys and only 2.3 per cent in agriculture as compared with 30. On the other hand a considerable number of city boys, 4.3 per cent, are interested in forestry. Very few are thinking of fisheries or mining.

The occupations second in appeal to the country boy are those of the technical engineer, including automotive engineering, chemical, civil, electrical, mechanical, mining, aeronautical and radio engineering, and simply "engineering." Approximately 26 per cent of the country boys in the town high schools preferred technical engineering as an occupation. A considerably larger number of the freshmen group, or 36 per cent, are interested in it, 19 per cent of the sophomores, 23 per cent of the juniors, and 28 per cent of the seniors. Those experienced in Land Grant Colleges and Universities have recognized that country boys constitute a large proportion of those enrolled in technical engineering.

On the other hand, even a larger proportion of the city boys, or 35 per cent, express preferences for technical engineering. More city boys choose engineering than any other occupation. They see more of construction work and industrial engineering than do the country boys and this unquestionably influences their choice. Thirty-one (31) per cent of the freshmen expressed preference for engineering and 39 per cent of the seniors, this being the reverse of the situation with the country boys in which group 36 per cent of the freshmen and 28 per cent of the seniors expressed preference for engineering.

Within the group that would choose engineering a larger proportion both of country and of town boys are interested in aeronautics than in any other type of engineering. In fact a larger proportion of all the town boys expressed preference for aeronautics than for any other single enterprise, and with the exception of the agricultural occupations, the country boys did likewise, 12 per cent of the town, and 13 per cent of the country boys expressing preference for aeronautics. The unusual and the venturesome aspects of aeronautics, the beauty and intriguing mechanics of the airplane, appeal to the spirit of the American boy whether from the country or town.

For the country boy the skilled occupations and the professions, including research and scientific service, law, medicine, the ministry, dentistry, pharmacy, journalism, music and teaching, have a considerable appeal, 10 per cent expressing preference for the occupations in this group. Among

the city boys the proportion is higher, nearly 17 per cent. In both instances the interest in the professions apparently is larger in the upper two years of high school work than in the lower. Neither group is greatly interested in teaching, but the city boy is less so than the country boy, only 1 per cent of the former and 3 per cent of the latter expressing a preference for this profession.

A miscellaneous group of occupations including those of the army and navy, secretarial and clerical work, professional sports, direction of physical education and coaching, and a number of unclassified occupations, attract 7 per cent of the country boys and 11 per cent of those from the town.

Civil service, banking, insurance, salesmanship, retail business and executive occupations appeal to 5 per cent of the country boys and 10 per cent of those from the town. The proportion interested in commercial occupations seems very small. On the other hand, it is quite logical that more of the city boys who everyday come in contact with commercial enterprises are interested in thes as a life's calling than the country boys who have opportunity to observe such activities only occasionally on their trips to town.

Quite as interesting as the vocational preferences are the reasons given for them. Interest and belief in enjoyment and pleasure to be derived from occupations are the reasons most often mentioned. In the case of the country boys, 39 per cent indicated pleasure in the occupation named, and 20 per cent interest, as the reason for their choice, and among the town boys 34 per cent expressed their preference because of belief in enjoyment to come in the occupation selected and 34 per cent because of interest. In other words, interest and enjoyment together, were given as the reason for the choice on the part of 59 per cent of the country boys and 68 per cent of the boys from the town.

The fact that relatives were in the same occupation influenced 25 per cent of the country boys in their choice and 14 per cent of the town boys. The realization that there were special opportunities for them in certain occupations because of some family relationship, or other personal advantage, influenced 8 per cent of the country boys and 9 per cent of those from the city. One might ask the question "Are not these boys also interested in the income to be derived from the various occupations?" According to the replies returned, this is the case to a limited degree only. Only 7 per cent of the country boys and 8 per cent of the boys from the town indicated that this was a factor in their choice. That perhaps is as good an illustration of the idealism of American youth as one might wish to have.

Only 4 per cent of the country boys and 9 per cent of the town boys gave no reason for their choice. But quite a large percentage, 40 of the country boys, and 39 of the boys from the town to whom this questionnaire was presented, made no reply. Since the directions to them were that no reply should be given if they had no specific preference, this undoubtedly influenced a large number. On the other hand, high school boys are in the formative period and for many the preferences for a vocation have not yet crystallized. The influence of parents, teachers, vocational directors, and friends here are all important.

More or less detailed reasons were given by some boys for their preferences, although this was not requested. A few illustrations perhaps will be of

interest. Boys living on their own farms who indicated that farming was their choice had reasons of this character: "My reason is that farming keeps one doing something and I like livestock and agriculture"; "I like agriculture better than any other and I think there will be more money in it someday"; "I have some land, better use it"; "It is out in the open, it pays good and is not a steady drudge at one thing"; and "You are your own boss and the work is mostly outside." A town boy who is interested in farming gives this as his reason, "Because you're your own boss, have the hours you wish, and can't go hungry if not lazy." The outside employment, the fact that agriculture is not monotonous, that in farming one changes from one job to another, and the traditional independence of the farmer, apparently have their appeal to boys both from the country and the town.

On the other hand, one who lives on an owned farm and who is ambitious to become a pattern maker, says, "I'm disgusted with farming and prefer some occupation of a steadier income."

In one town a number of boys expressed interest in undertaking. One of them wrote, "People have to die, too many people in other lines of work," and another one, "Funeral directing is interesting!"

A city boy who loves the out of doors wants to become a naturalist and gives as his reason, "I like to meditate with nature." Another city boy wants "to develop the natural resources of South America because it is not thoroughly civilized and has lots of natural resources undeveloped." A third wants to become an explorer in Africa because he has read Martin Johnson's books.

Two boys from the country who have selected the ministry as their profession express their reason in this way, "I desire to benefit my fellow men" and "I was encouraged to do so by our pastor and my mother, and I have always wanted to do it." Analogous to the reasons given for choosing the ministry as a life's work are those given by one who wants to become a lawyer because of "the appeal of doing something which would enable him to help others" and by another who is planning to teach, because he "would like to broaden the minds of people!"

A town boy who wishes to become a doctor says, "It is a good field, interesting and something earned after some good hard labor."

The effect of today's economic situation is reflected in the replies of a number who are interested in civil service. One boy is interested in government service, because "there are no layoffs, no salary cuts, interesting work," another because it "is a good steady job with retirement afterwards", a third, because he knows he "will have a pay day each month", and a fourth, because "The post office department offers year 'round employment and a steady salary regardless of economic conditions." A few years ago these boys perhaps would not have given a thought to civil service and a steady salary.

While final conclusions as to vocational preferences are not made in this report and will await more comprehensive study of the large volume of data secured, the samples used in this paper probably are fairly representative. The study indicates that there are no fundamental differences in choice of occupations between country boys and city boys, except that a larger proportion of the former are interested in agriculture to a greater or lesser degree. Both groups are influenced by the type of occupations and

(Continued on page 12)

The Value of the Hybrid Wheats Produced By The State College of Washington[1]

by
E. F. GAINES
State College of Washington

Introduction

PROFESSOR Thatcher in his introductory note to Washington Station Bulletin 89 wrote: "The original plan of the (wheat improvement) work was conceived by Professor Spillman and the earlier crosses and selections were made by him personally or under his supervision. Following his departure from this institution the work of selection, propagation, and field trials of the original hybrids, together with the production of many new crosses, has been carried out by several new members of the Agricultural Department of the Station."

Without the impetus of Spillman's vision and enthusiasm it is doubtful that the Agricultural Experiment Station of the State College of Washington would have attained the position it now holds as a pioneer in plant breeding and crop improvement work.

Professor Spillman laid out the basic principles of procedure that are followed to the present day.

During the summer of 1901 he discovered the laws of segregation and recombination of characters, as the three European botanists, Correns, von Tschermak, and de Vries had done independently in the Old World the year previous. Without knowing of the similar work of Mendel published in 1866 these four scientists rediscovered the principles now known as Mendel's Laws. It was a time when experimental research had advanced to a stage that could appreciate the importance of these discoveries and during the 30 years following they have been abundantly verified by many scientists both in America and in Europe, as well as other parts of the world. Spillman was the first agriculturist to discover and apply Mendel's Laws to the improvement of farm crops. He started out to develop a winter-hardy, stiff-strawed, non-shattering, prolific wheat. The scientific discovery and the popularizing of hybridization as a means of crop improvment throughout the United States was a byproduct of an altruistic and utilitarian ideal. It is the purpose of this paper to make an estimate of the value of this work emanating from the State College of Washington during the last 25 years.

The Common Wheats in the Pacific Northwest Which the College Hybrids are Replacing

When Spillman made his first crosses in 1899 Little Club was the principal variety of wheat in areas above 20 inches of rainfall, and Pacific Bluestem was the principal variety in areas below 17 inches. In the section in between, Red Chaff predominated, with more Little Club in the regions of higher rainfall and more Bluestem towards the drier areas. These varieties were all spring wheats although in mild winters they would live through when sown in the fall. Ten years later when the new bybrids were beginning to be established three

[1]Presented at the annual meeting of the Northwest Scientific Association, December 28-29, 1932, Spokane, Washington. Published as Scientific Paper No. 244, College of Agriculture and Experiment Station, State College of Washington.

winter wheats, Fortyfold, Red Russian, and Jones Fife, had made their appearance in the Little Club and Red Chaff areas and were replacing them on many farms. Jones Fife was replacing Bluestem in the areas of light rainfall in seasons favorable for winter wheat.

Two additional wheats, Turkey and Jenkin, became widely grown during the years that the college hybrids were gaining headway. Turkey still holds the leading place among winter wheats in the drier areas.

The New Wheats Developed by the College

Professor Spillman in Bulletin 89 lists 15 hybrid selections that were given field tests from 1905 to 1908. Hybrid 123 and Hybrid 108 came to be known as the Red Hybrids because the grain was red, while Hybrids 60, 63, 128, and 143, having white grain, were called White Hybrids. All had stiff straw, were winter hardy, prolific, and resistant to shattering. These hybrids were all descendents from the original crosses made by Professor Spillman and H. F. Blanchard in 1899, and were of the Club type, *Trticum compactum,* Host.

While they were being selected, tested, and distributed many new crosses and recombinations of the old ones were being made and tested, but it was not until 1918 that Triplet was sent out to compete with the now famous Club wheats that had spread over one-third of the winter wheat area of the Pacific Northwest.

Triplet is not a Club wheat, but has a long head with hairy chaff and red grain. Its strong points are winter hardiness and ability to yield more than the Spillman hybrids. All winter wheats grown commercially up to 1924 were quite susceptible to smut with the exception of Turkey which was fairly resistant but which had such weak straw that it was not suited to the principal winter wheat sections of Washington.

The first smut resistant hybrid to be sent to farmers from the Washington experiment station was Ridit, distributed in 1924. Ridit has a long head, smooth white chaff, and large hard red kernels. It does not yield quite as well as some of the older hybrids, but is resistant to smut and the higher gluten content of the grain gives it a higher average market value.

In 1927 Albit was introduced. It is a club wheat with white grain—much like its mother parent, Hybrid 128, except that it is resistant to some forms of smut.

The distribution of seed of the college hybrids to farmers began in the fall of 1907. Professor Spillman in Bulletin 89 quotes from the reports of a dozen farmers to the effect that the new hybrid wheats had stiffer straw and better grain and produced from 10 to 15 bushels per acre more than the old varieties, Red Russian and Little Club. The white hybrids, 63 and 128, as well as the two red hybrids, 108 and 123, were mentioned specifically in these reports. President E. A. Bryan in a letter to Spillman in February, 1909, estimated that 39,000 acres were sown with seed of the college hybrids in the fall of 1908. By 1911 when the writer assumed charge of the breeding work, the college hybrids were widely grown in Washington, and had spread to the adjacent states of Idaho and Oregon. Careful estimates place the total acreage by this time at 150,000 acres for the hybrid wheats. The price differential in favor of white wheat combined with the somewhat greater yield caused the white hybrids, 128 and 143, to be increased more rapidly than the red; and in the following years Hybrid 128 led all others in total production.

Surveys made in the years 1918 and 1919 placed the percentage of the total crop of Washington contributed by the college hybrids as follows:

Hybrid 128	11.5 per cent
Hybrid 143	3.4 per cent
Hybrid 63	2.4 per cent
Hybrid 123	1.8 per cent
Total	19.1 per cent

The college has sent out 12 hybrid wheats to farmers for testing during the 25-year period, 1907 to 1923. The farmers have approved of seven of these to the extent that at the height of their popularity more than 1,000,000 bushels of each were grown. The total production of the hybrid wheats for Washington, Idaho, and Oregon this year (1932) is estimated to be more than one-third of the total wheat crop, as shown in Table 1.

Table 1. The Seven Most Important Hybrids Produced by the Washington Agricultural Experiment Station, With Parentage, Year Distributed, and Present Production.

Name	Percentage	Year distributed	Production in 1932 bus.
Albit	Hybrid 128 x White Odessa	1927	12,500,000
Hybrid 128	Jones Fife x Little Club	1907	8,500,000
Ridit	Turkey x Florence	1924	7,000,000
Triplet	$\frac{\text{Jones Fife}}{\text{Little Club}} \times \frac{\text{Jones Fife}}{\text{Turkey}}$	1918	4,000,000
Hybrid 123	Jones Fife x Little Club	1907	500,000
Hybrid 143	White Track x Little Club	1908	400,000
Hybrid 63	Turkey x Little Club	1907	100,000

Hybrids 143, 123, and 63 are rapidly disappearing and Hybrid 128 and Triplet are grown on less than half the area they occupied five to eight years ago. The four hybrids of importance at the present time are Albit, Hybrid 128, Ridit, and Triplet, representing approximately one-third of all the wheat grown in the Pacific Northwest. Hybrid 123 is the most important red club hybrid and is unique in that it may be planted either in the fall or in the spring and yet produce a satisfactory crop. It is the only commercial variety of wheat in the Pacific Northwest that is well adapted for such use.

Comparative Yields

Wheat varieties have been tested for yield at Pullman in field plots as well as in rows for many years. These plots and rows have been replicated two to four times each year to counteract soil variations and lessen experimental error. During the last 19 years the five hybrids, Albit,* Triplet, Hybrid 128, Hybrid 123, and Ridit,* have averaged 18.3 per cent more wheat than the old standard wheats, Jones Fife, Fortyfold, Red Russian, and Little Club, that they have replaced. Expressed in bushels per acre, they have outyielded the old varieties each year from 2.1 to 10.3 bushels per acre, as indicated in Figure 1, with an average of 6.3 bu. Tests have also been conducted in various sections of the wheat producing areas of the three states, especially

*Note. Albit and Ridit have been under test only since 1924 and 1919 respectively, but since they are now of such great economic importance they are included for the years in which yields were obtained.

during recent years, at some 30 different points. These tests confirm the experiences of farmers and show that in most instances they are growing the varieties best suited to their particular localities.

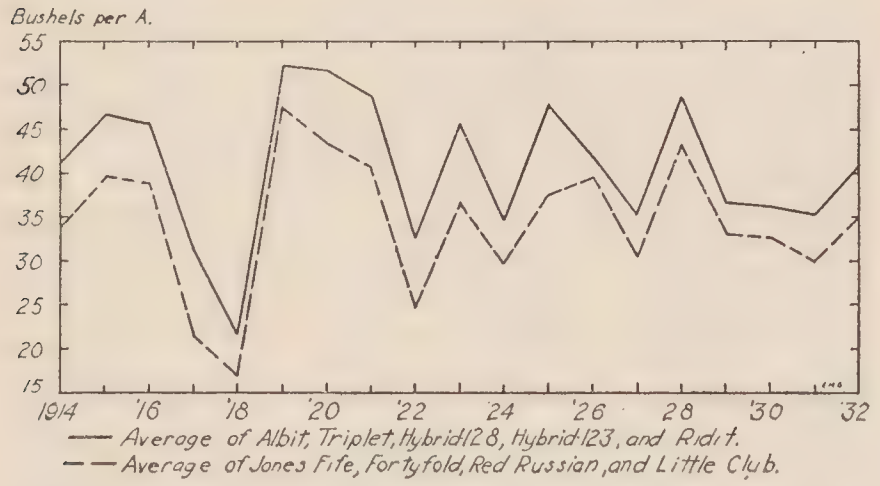

Fig. 1. Comparative yields of college hybrids and varieties they have replaced

The data have not been brought together from all the outlying stations because of difficulties of organization and state boundaries, but since Pullman is in the heart of the area producing the hybrid wheats the comparisons given may be considered representative.

Table 2. Source of Data from Which Total Production of College Hybrids in Washington from 1908 to 1932 Was Estimated (Washington Bulletins 89, 159, 224, 256).

Year of survey	Total crop per cent	Production Bushels
1909	2.5	1,555,000
1918	19.1	6,298,326
1919	"	"
1921	27.1	14,786,000
1922	30.6	9,847,578
1923	28.1	17,600,882
1926	26.8	10,420,214
1929	42.7	18,153,253

Increased Production Resulting From College Hybrids

Since 1908 when the first hybrids from the Spillman crosses were grown by farmers there has been a gradual increase in the acreage of the new wheats in Washington as shown by Table 2. Oregon and Idaho farmers have also grown large quantities of the W.S.C. Hybrids—probably one-fifth of their total crop last year. In 1932 the amount grown is estimated at 38 per cent of the total wheat of the three northwestern states, 36,864,000 bushels. As shown in Figure 2, this is almost half the winter wheat.

The question may be raised, to what extent the college hybrids have actually increased the number of bushels produced in the Pacific Northwest. If it is assumed that the 18.3 per cent superior yield in the variety tests at Pullman is representative of the increase on the entire acreage sown to

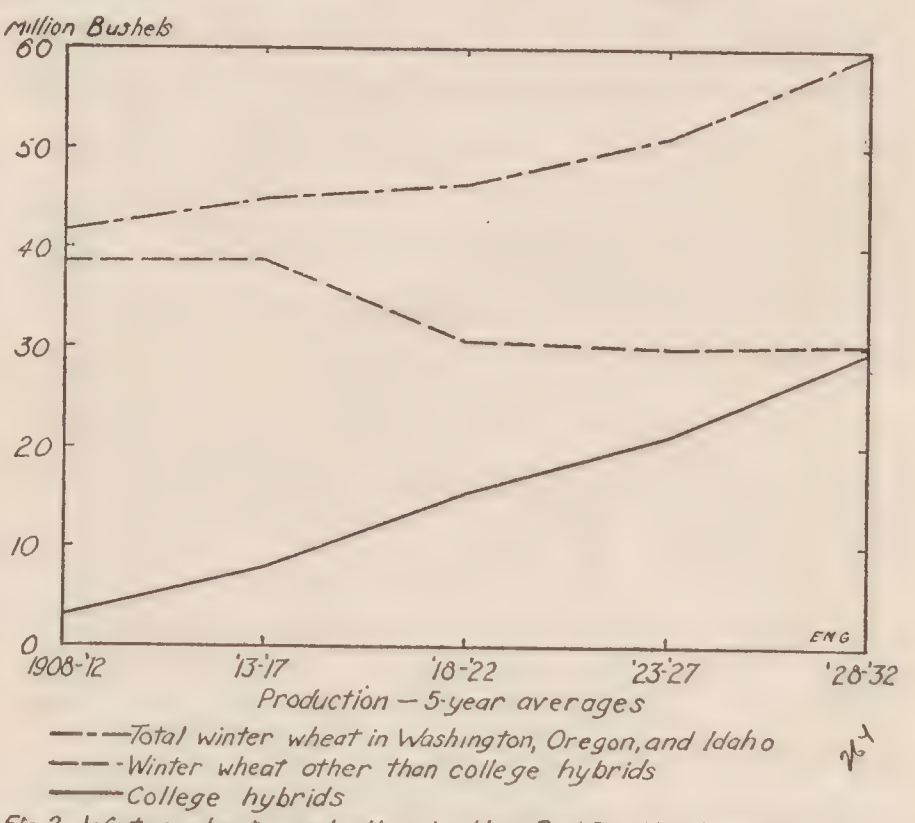

Fig. 2. Winter wheat production in the Pacific Northwest during the last 25 years.

the college hybrids, then there would have been produced only 81.7 per cent as much wheat of the old varieties if they had been grown instead of the hybrids. In other words the 36,864,000 bushels of hybrid wheats produced such as Jones Fife, Fortyfold, Red Russian, and Little Club. The cumulative effect in the last 25 years would have been 70 million less.

It is hardly to be expected that there would be as much difference as 18.3 per cent between the old and new wheats in localities far removed from Pullman, but there must have been some advantage or farmers would not have grown the hybrids. Suppose we

take the conservative figure of 10 per cent as the average superiority of the college hybrids. The value at 10 per cent would have increased as the acreage increased from nothing to nearly four million bushels annually. The average annual increase resulting from the hybrids for the last 25 years would have been a little more than one and one-half million or a total of 38,636,000 bushels during the last 25 years. The average price per bushel during this time was 98.5 cents per bushel. Thus the college hybrids have probably added somewhere between $38,000,000 and $70,000,000 to the wealth of the Pacific Northwest during the 25 years just past. Table 3 shows the sum total of the new wheats grown and cash value in Washington, Oregon, and Idaho from 1908 to 1932 as based on the surveys summarized in Table 2.

Table 3. Total Production and Value of the W.S.C. Hybrids During the 25-Year Period, 1908 to 1932.

State	Production bushels	Value in dollars (Dec. 1 price to farmers)
Washington	245,613,000	235,069,000
Oregon	88,188,000	97,960,000
Idaho	52,563,000	47,553,000
Total	386,364,000	380,582,000

Other Advantages of the New Wheats

Spillman bred for greater winter hardiness, stiffer straw, non-shattering head, and better weight per bushel. The last two hybrids, Ridit and Albit, were bred for resistance to smut. The new wheats excel in all these respects for which they were selected. They average 1.7 pounds per bushel heavier, yield 1.6 per cent more flour, the bread averages 55 cc. greater volume per loaf, with 3.1 per cent better texture; the straw is slightly stiffer, the heads are 6 per cent more resistant to shattering, and Ridit and Albit are very resistant to smut. The older hybrids, 128, 123, and Triplet, are similar to Jones Fife, Fortyfold, Red Russian, and Little Club, in their susceptibility to smut. Perhaps the most valuable advantage of the hybrids thruout the last quarter century is their greater winter hardiness. A good survival resulting in a uniform stand not only assures a good crop, but tends to smother weeds and retard erosion. The added cost of seed and labor in resowing a field in the spring on account of winter-killing has not been estimated in enumerating the advantages of the new wheats, but many times the old varieties have frozen out badly when the hybrids came through the winter with good uniform stands.

Stinking smut is the most dreaded disease in wheat in the Pacific Northwest. During recent years smut has been on the increase everywhere in the United States except in the Pacific Northwest where, on account of the resistance of Ridit and Albit, there has been a pronounced decrease. The saving in smut dockage which has not been included in the above estimates is a large item in this territory.

VOCATIONAL PREFERENCES OF STUDENTS

(Continued from page 7)

activities they see around them, as agriculture in the case of the country boy, and technical engineering, the city boy. The venturesome spirit of both turns to aeronautics as a means of realization of dreams of action and adventure. The most potent factors in the choice of both groups are interest and enjoyment in the vocation preferred, and the fact that relatives and friends are engaged in these occupations. Financial return holds a minor place as a determining factor in the choice of vocations by high school students.

First Settlers' Petition From The Oregon Country[1]

By

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University of Idaho

Introduction

THERE was no semblance of governmental activity or organization in Oregon for a decade following the arrival of the Astorians in 1811. On July 2, 1821, the English Parliament passed an act chartering the combined Hudson's Bay Company and the North West Company.[2] Dr. McLoughlin was appointed Chief Factor of the Columbia District of the Hudson's Bay Company in 1823, and arrived at Fort Vancouver in 1824.[3] By reason of his office he assumed virtual dictatorship of the Oregon country, deriving his authority as Chief Factor from the charter of the combined companies,[4] and his civil authority from the Act of English Parliament of December 21, 1821, regulating the fur trade in Northwestern North America.[5]

There remained in Oregon a few American settlers who had accompanied early expeditions and a small number who had come as independent travelers or adventurers by land and sea. Over these Americans McLoughlin neither had, nor attempted to exercise, any authority. The first permanent American settlement was made by Jason Lee, head of the American Methodist Missionary party, which, in 1834, established a mission station and settlement ten miles northwest of the modern Salem. This small missionary settlement was robustly American, and from the outset, was opposed to the rule of the British Hudson's Bay Company; the missionaries being actively devoted to religious and educational work, the Hudson's Bay Company's employees being engaged in strictly commercial activities.[6]

The Treaty of Ghent, in 1814, agreed that the rights and activities of the citizens of Great Britain and America should not be interfered with by either government. Under this agreement citizens of either country were free to organize their own communities. The factors of the Hudson's Bay Company and of the North West Company, as already mentioned, acted in the dual capacity of business managers for their employers and as civil agents of their government. At the American mission station in the Upper Willamette Valley, the Reverend David Leslie[7] was elected probate judge for the American community as early as 1838.[8]

From the foregoing facts it will be seen that beginning with the Astor settlement in 1811, and especially from the date of the restoration of that fur trading post to the Americans in 1818, there was an active struggle between the British and the American interests for control of the Oregon country. In

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[1]Presented at the annual meeting of the Northwest Scientific Association, December 28-29, 1932, Spokane, Washington.

[2]Article VIII, Parliamentary Act of 1821 quoted in Robert Greenhow, *The History of Oregon and California* (Boston, 1845), pp. 469-470; *Oregon Historical Society Quarterly,* (30 vols., Portland), XIII, pp. 91-92; Hubert H. Bancroft, *History of the Northwest Coast* (2 vols., San. Francisco, 1886), II, p. 303.

[3]L. J. Burpee, *The Makers of Canada* (12 vols., New York, 1926), XII, p. 396; Frederick V. Holman, *Dr. John McLoughlin, the Father of Oregon* (Cleveland, 1907), p. 27; McLoughlin "Copy of a Document" (*Oregon Pioneer Association Transactions,* 1873-1916; 1918-1919, Salem, Oregon. 1887-1929, Portland). *Transactions . . . for 1880.*

[4]*Deed Poll* Articles I to VIII; Bancroft, *Northwest Coast,* II, pp. 307-8.

[5]Greenhow, *Oregon,* p. 467.

[6]Its officers were mainly Episcopalian, although Dr. McLoughlin was descended from Catholic antecedents, and later, about 1842, formally joined the Catholic church. Holman, *Dr. John McLoughlin,* p. 98.

[7]The Reverend David Leslie (1797-1869) arrived in Oregon in 1837.

[8]Hubert H. Bancroft, *History of Oregon,* (2 vols., San Francisco, 1884), I, p. 236.

the winter of 1836-1837, Lieutenant William A. Slacum, a purser in the United States Navy, arrived in Oregon. Having received his instructions from the Department of State, his arrival marked the first formal expression of a new interest in Oregon by the executive department of the federal government.

It was doubtless a natural sequence of events that the first Settlers' Petition or the OREGON MEMORIAL OF 1838, the first[9] formal expression from resident Oregonians for an American Oregon, should have followed so closely upon Slacum's visit. Indeed, there is much evidence pointing to the conclusion that it was Slacum's expedition which influenced Superintendent Lee to return to the East in the spring of 1838; and that it was Slacum who suggested *the idea of a Settlers' Memorial.* On his eastward journey Lee carried the pioneer document which had been drawn up in convention. The careful preparation of the MEMORIAL in anticipation of Lee's journey east further confirms the belief that in Lee's decision to return to the Atlantic states there were other factors[10] than those relating directly to his mission. Not least among these was, doubtless, the visit of William A. Slacum.

To understand the significance of Slacum's visit it is necessary to know that in November, 1835, he was requested by President Jackson, acting through John Forsyth, Secretary of State, to make a report on the Oregon country.[11] Forsyth's written orders to Slacum were brief and general, while the actual report which Slacum made is complete and detailed. It is evident from this that he probably had oral instructions from Forsyth or President Jackson, or from both.

President Jackson's interest in Oregon has been traced to his desire to resist British aggressions. A document reflecting this attitude in his message to Congress in 1831, which includes letters of different western traders.[12] His keen interest as early as the autumn of 1835, has been attributed to Hall J. Kelley's reports,[13] and to Captain B. L. E. Bonneville's expedition to Oregon,[14] from which region that traveler returned in the late spring of 1835.

Lieutenant Slacum reached the Columbia River on December 22, 1836. He proceeded to Fort Vancouver where he was courteously received by Dr. John McLoughlin. While there he made careful observations of the fort, its location, trading operations,

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[9]The statement is frequently made that a Settlers' Memorial was framed early in 1837 and given to Slacum to present to Congress. Careful investigation by the writer in every department of the federal government in Washington, D. C., failed to disclose any such Memorial on file. If Slacum was given such a petition, he did not include it in his Memorial; and if filed by him it has since been lost. Later incorrect references to this alleged Memorial of 1837 seem to be based on Daniel Lee's mention of it. See Daniel Lee and J. H. Frost, *Ten Years in Oregon* (New York, 1844), p. 144.

[10]Bancroft, *Oregon,* I, p. 166. A. J. Allen (Comp.), *Ten Years in Oregon; Travels and Adventures of Dr. E. White and Lady* (Ithaca, 1850). Dr. Elijah White, one of the Memorialists, wrote that it "was predicted by some on that day when the Memorial was framed that the Petition would draw upon Oregon hundreds of immigrants".

[11]*Senate Executive Document,* 24th and 25th Congress, 2d Session, Vol. I, contains Slacum's MEMORIAL. The MEMORIAL is accurately reprinted in *Oregon Historical Quarterly,* XIII, pp. 174-225.

[12]*Senate Ex. Doc.* 29, 21st Congress, 1st Session, 1831, I.

[13]Bancroft, *Oregon,* I, p. 99, L. B. Shippee, "Federal Relations with Oregon," *Oregon . . . . Quarterly,* XIX,, p. 222.

[14]William J. Marshall, *Acquisition of Oregon* (2 vols., Seattle, 1911), I. p. 195. F. G. Young makes this editorial comment: . . . "The investigations of Dr. J. R. Wilson led him to look upon this effort of President Jackson to get light on the situation in Oregon as bound up with his larger scheme of territory in the southwest, stretching from Texas to and including the harbor of San Francisco. Doctor Wilson came to the conclusion because Jackson's interest in this direction had in the first instance been aroused by letters from Slacum". Introductory editorial note by F. G. Young on Slacum's "Report on Oregon," 1836-7. *Oregon . . . Quarterly,* XIII, p. 175. Bonneville arrived at Independence, Mo., on April 22, 1835. He was in Washington, D. C., in the early autumn. Through President Jackson he won his campaign for reinstatement in the army. It was probably Bonneville's activities in connection with his aggressive campaign for reinstatement that reawakened Jackson's interest in Oregon in the autumn of 1835.

stock, Indian slaves, and other features relating to the live and activities of the "Great Company".

After spending about ten days at Fort Vancouver, Slacum decided to visit the only white settlement on the Willamette River. January 12, he reached "Camp Maud du Sable", [Campment Du Sable or Champoeg], where he met Jason Lee who had journeyed eighteen miles down the river from his mission house to greet him.[15] Lee and Slacum were joined in friendly relationship while engaged in promoting the cause of temperance sponsored by Lee as early as 1836.[16]

A second common interest that drew these leaders into friendly association was their effort to promote the future economic growth of Oregon. To this end they held conferences on the subject of the organization of a cattle company, a fact confirmed by Slacum's own words.[17]

Slacum's offer to assist the American settlers was quickly accepted and a meeting was called for all those interested in joining the undertaking. They met at Champoeg and organized the Willamette Cattle Company, with Ewing Young as leader and P. L. Edwards as treasurer.[18] Approximately $2700 was contributed, which would enable them to purchase eight hundred head of cattle in California. Of this amount, $500 was advanced to Jason Lee by Slacum and nearly $900 was added by Chief Factor McLoughlin of the Hudson's Bay Company.[19]

Slacum's report also gives expression to the fact that he shared with Lee's missionaries the view that the federal government should take an aggressive stand for the possession of Oregon.[20]

The MEMORIAL thus testifies emphatically to the cordial personal relations existing between Jason Lee and Oregon's first visitor from the national government.[21] Slacum's good will for Lee is reflected in this statement:

> It affords me great pleasure to add, that every white man in the settlement entertains the highest respect for the character and conduct of the Lees and their associates.

Lee's recently discovered letter written to the corresponding secretary of his mission board, introducing Slacum and requesting that a cordial welcome be extended to him, furnishes further evidence on this same point:

> For particulars concerning the present prosperity of the mission I must refer you to Mr. Slacum, who is bound for California, through Mexico, to the United States, . . . I shall give him a letter of introduction to you; and I hope for our sake, and the sake of the mission, you will show him all the attention in your power, for he takes a great interest in our mission, and his representations to the government may be of service to us and to the country.[22]

Slacum's appearance on the same platform with Lee, on the occasion of Lee's lecture appointment at Philadelphia on December 4, 1838, is further confirmation of this same friendly relationship and discloses the fact that they were in touch with each other while Lee was in the Philadelphia area in early December, 1838, since on Lee's invitation Slacum had a place of honor on the program on the occasion of

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[15]Slacum, *Memorial,* p. 11.

[16]Slacum, *Memorial,* p. 12. On January 2, before the arrival of Slacum, a Temperance Society had been formed and its resolutions signed by Lee and others. Slacum made it possible for Young and Carmichael to take the alternative of going to California in place of continuing the operation of their distillery.

[17]Slacum, *Memorial,* p. 12.

[18]Lee to Mission Board, *Christian Advocate and Journal* (New York, 1826 to date), June 9, 1837, XI, p. 166.

[19]Bancroft, *Oregon,* I. p. 141; McLoughlin, "Copy of a Document," *Transactions for . . . 1880,* pp. 51, 52.

[20]Slacum, *Memorial,* p. 17.

[21]*Ibid.,* p. 12.

[22]*Christian Advocate,* June 9, 1837, XI, p. 166, Corresponding Secretary Nathan Bangs wrote this foot note when transmitting Lee's letter for publication: "I have seen this gentleman, and received the most flattering account of the prosperous state of the mission".

Lee's widely heralded lecture on Oregon.[23]

The following comment by Lee in his letter of January 18, 1837, to his Board, also points clearly to the conclusion that Lee viewed "this new and lovely country"[24] of Oregon as the home of a future white civilization:

> I am fully of the opinion that this country will settle ere long; and if you can send us a few good, pious settlers, you will aid us essentially in laying a good foundation for time to come, and confer an incalculable benefit upon the people, which will be felt by generations yet unborn. Pious men we want, and must have to superintend our boys in their labor; but they are not to be had here at present.
>
> Send out more laborers for the temporal and spiritual field. Call loudly upon the people for men and means.[25]

It seems clear from the foregoing statements that the controlling elements in Lee's decision to return to the East in the spring of 1838 were his desire to promote the welfare of his mission *and the advisability of bringing vividly to the attention of Congress the matter of the desirability of Oregon as a place of residence.*

The person who "inspired" or brought about the framing of the MEMORIAL was doubtless Superintendent Lee, official head of the Methodist mission. There is no known evidence, however, that he actually wrote any portion of it. In the BancroftLibrary, University of California, is a booklet[26] written by P. L. Edwards, entitled *A Sketch of the Oregon Territory or, Emigrants' Guide* and published at Liberty, Missouri, in 1842. On pages 13 and 14, Edwards makes this definite statement concerning his authorship of the Memorial:

> In a memorial to the Congress of the United States, presented by Dr. Linn in the winter of 1838-9, and which I drew up for the settlers before I left the Territory, . . .

There is no known evidence that Edwards had any assistance in drafting the document. Edwards, who had the honor of achieving distinction as a citizen in the three states of Oregon, Missouri and California, was only twenty-six years of age when he wrote this historic settlers' petition.[27]

The Oregon Settlers' Petition constitutes one of the most influential documents which received publication during the history of the Oregon Boundary Controversy. Its appearance was timely, since little first hand information from Oregon was available at the time of its publication.

The Settlers' Petition appeared at a time when interest in Oregon was deep. The panic of 1837 had created a restless population in many sections of the Middle West and East who were eager for news concerning Oregon. Moreover, an appeal for an American flag over far-away Oregon from a small group of Americans in a little log mission house could not help but cast its spell over the American people.

The MEMORIAL of 1838 marked the first effort by resident Oregonians in a diplomatic contest which, nearly a decade later, terminated in the solemn Treaty of 1836, which settled between two great English speaking nations the "metes and bounds" of the vast region along the northwest coast of North America.

The Oregon Memorial of 1838

January 28, 1839.

To the honorable the Senate and House of Representatives of the United States of America:

The undersigned, settlers south of the Columbia River, beg leave to represent to your honorable body:

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[23] *Christian Advocate,* January 4, 1839, XIII, p. 77.

[24] In letter to his board, March 27, 1843.

[25] Lee in letter to Corresponding Secretary Nathan Bangs, *Christian Advocate,* January 18, 1837, XI, p. 166.

[26] Described in Bancroft, *Oregon,* I. p. 169, as a "manuscript".

[27] "Colonel Philip Leget Edwards . . . and the Far West", by C. L. Camp, *California Historical Society Quarterly,* (San Francisco, 1922 to date), April-December, 1924, III, p. 78.

That our settlement began in the year 1832,[28] and has hitherto prospered beyond the most sanguine expectations of its first projectors. The products[29] of our fields have amply justified the most flattering descriptions of the fertility of the soil, while the facilities which it affords for rearing cattle[30] are, perhaps, exceeded by those of no country in North America. The people of the United States, we believe, are not generally apprized[31] of the extent of valuable country west of the Rocky Mountains. A large portion of the territory from the Columbia River, south, to the boundary line between the United States and the Mexican republic,[32] and extending from the coast of the Pacific about two hundred and fifty or three hundred miles to the interior, is either well supplied with timber or adapted to pasturage or agriculture. The fertile valleys of the Willamette[33] and Umpqua[34] are varied with prairies and woodland, and intersected by abundant lateral streams, presenting facilities for machinery.[35] Perhaps no country of the same latitude is favored with a climate so mild.[36] The winter rains,[37] it is true, are an objection; but they are generally preferred to the snows and intense cold which prevail in the northern parts of the United States. The ground is seldom covered with snow, nor does it ever remain but for a few hours.

We need hardly allude to the commercial advantages of the territory. Its happy position for trade with China,[38] India, and the western coasts of America[39] will be readily recognized. The growing importance, however, of the islands of the Pacific is not so generally known and appreciated. As these islands progress in civilization, their demand for the produce of more northern climates will increase. Nor can any country supply them with beef, flour, &c.,[40] on terms so advantageous as this. A very successful effort has been recently made at the Sandwich Islands, in the cultivation of coffee and the sugar cane.[41] A colony here will, in time, thence easily derive these articles and other tropical products, in exchange for the produce of their own labor.

We have thus briefly alluded to the natural resources of the country and to its external relations. They are, in our opinion, strong inducements for the Government of the United States to take formal and speedy possession. We urge this step, as promising to the general interests of the nation; but the advantages it may confer upon us, and the evils it may avert from our posterity, are incalculable.

Our social intercourse has thus far been prosecuted with reference to feelings of honor,[42] to the feeling of dependence[43] on the Hudson's Bay Company, and to their moral influence. Under this state of things, we have thus far prospered; but we cannot hope that it will continue. The agricultural and other resources of the country cannot fail to induce emigration and commerce. As our settlement begins to draw its supplies through other channels, the feeling of dependence upon the Hudson's Bay Company, to which we have alluded as one of the safeguards of our social intercourse, will begin to diminish. We are anxious when we imagine what will be—what must be—the condition of so mixed a community, free from all legal restraint, and superior

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[28]Some members of Wyeth's party settled in Willamette Valley in 1832.

[29]As early as 1838 the Willamette Valley was producing "good English grain," i.e., wheat and oats; but because of the cool nights the region was "not suited to Indian corn."

[30]Willamette Valley produces an abundance of grass and herbage suited for cattle raising. No winter feeding is needed.

[31]Bryant's "Thanatopsis" (1817) listed "The Oregon" (the Columbia River) with the "Barcan Wilderness" in North Africa as among the remote portions of the earth. Bryant used no poetical exaggeration. At the opening of the nineteenth century the Oregon country rivaled the regions around the Arctic and Antarctic Circles as a *terra incognita.*

[32]In 1819 Spain ceded all claims to her territory north of the 42d parallel of north liatitude. The Mexican Republic was established in 1821.

[33]Willamette Valley is about 200 miles long and varies in width from a few miles to about 50 miles.

[34]Umpqua Valley lies farther south than the Willamette Valley.

[35]Water power development.

[36]The January isotherm of Portland, Oregon, is approximately the same as that of Washington, D. C.

[37]The so-called winter rains begin in September or October and continue until May or June.

[38]As early as 1785 American maritime merchants were carrying on trade with Canton, South China.

[39]This suggestion doubtless came from the memorialists such as David Leslie and Elijah White, who, on their outbound ocean journey to Oregon, had visited the important seaport of Valparaiso, Chili. Acapulco, Mexico, was the well known trading city on the west coast of Mexico. A brisk trade in hides and tallow, described so graphically by Dana in his *Two Years Before the Mast,* was carried on along the California coast.

[40]A herd of 630 head of Spanish cattle was brought from California to Oregon in October, 1837, and the foundations of an important industry were laid. As early as 1843, the Hudson's Bay Company shipped 10,000 bushels of Oregon wheat to Russia.

[41]The coffee plant was introduced into the Sandwich Islands about 1825. The sugar industry began with the making of sugar by a Chinese as early as 1802.

[42]Reference here is to absence of courts and organized law.

[43]The settlers were economically dependent upon the Hudson's Bay Company. An annual Hudson's Bay Company ship loaded with goods arrived at Fort Vancouver. This merchandise was sold alike to fur traders and settlers at a reasonable price. The Fort Vancouver store was the one general store in the country.

to that moral influence which has hitherto been the pledge of our safety.

Our interests are identified[44] with those of the country of our adoption. We flatter ourselves that we are the germe[45] of a great state, and are anxious to give an early tone to the moral and intellectual character of its citizens. We are fully aware, too, that the destinies of our posterity will be intimately affected by the character of those who emigrate to the country. The territory must populate.[46] The Congress of the United States must say by whom. The natural resources of the country, with a well-judged civil code,[47] will invite a good community; but a good community will hardly emigrate to a country which promises no protection to life or property. Inquiries have already been submitted to some of us, for information of the country. In return, we can only speak of a country highly favored by nature. We can boast of no civil code. We can promise no protection but the ulterior resort of self-defense. By whom, then, shall the country be populated? By the reckless and unprincipled adventurer—not by the hardy and enterprising pioneer of the West; by the Botany Bay refugee; by the renegade of civilization from the Rocky Mountains; by the profligate deserted seamen from Polynesia;[48] and the unprincipled sharpers from Spanish America. Well are we assured that it will cost the Government of the United States more to reduce elements so discordant to social order, than to promote our permanent peace and prosperity by a timely action of Congress. Nor can we suppose that so vicious a population could be relied on in case of a rupture between the United States and any other Power.

Our intercourse with the natives among us, guided much by the same influence which has promoted harmony among ourselves, has been generally pacific[49] but the same causes which will interrupt harmony among ourselves will also interrupt our friendly relations with the natives. It is, therefore, of primary importance, both to them and us, that the Government should take energetic measures to secure the execution of all laws affecting Indian trade and the intercourse of white men and Indians.

We have thus briefly shown that the security of our persons and our property, the hopes and destinies of our children, are involved in the objects of our petition. We do not presume to suggest the manner in which the country should be occupied by the Government, nor the extent to which our settlement should be encouraged. We confide in the wisdom of our national legislators, and leave the subject to their candid deliberations. And your petitioners will ever pray.

March 16, 1838.[50]

J. S. [L.] Whitcomb
James A. O'Neal [O'Neil]
J. M. Bates
Wm. Canning
John B. Deporles [Desportes] his X mark
Joseph Gervais, his X mark
Felix Hathaway
S. H. Smith
Ewing Young
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Daniel Lee
H. K. W. Perkins
Joseph Delord [De Lor]
Pierre Billique
Andre Picord
Joseph Delozhe [Deloze]
John Jean B. Perault [Perrault]
Ellienne Lucia [Etienne Lucier]
John Turner[51]

---

[44]The word "identical" incorrectly appears in numerous reprints of the MEMORIAL.

[45]The incorrect spelling in Cushing's "Report" is here followed.

[46]This statement was more than an optimistic utterance; it was an accurate prophecy. In 1842 came the Dr. Elijah P. White party of about 120 settlers known as the Emigration of 1842. This was followed by the "Great Emigration of 1843" of about 1,000 settlers.

[47]A civil code to safeguard property rights and business transactions; in contradistinction to a criminal code.

[48]Formerly the South Sea Islands.

[49]For two reasons: the fact that the Willamette Valley Indians were unenterprising, decimated by disease and decadent; and the presence of the firm rule of the Hudson's Bay Company.

[50]The date of the convention of Willamette Valley settlers who framed and signed the Memorial. Jason Lee set out from Oregon for the Atlantic states with the document ten days later on March 26. The later date, January 28, 1839, at the beginning of the document designates the time when the Memorial was ordered printed by the United States Senate.

[51]*House of Representatives Report No. 101,* 25th Congress, 3rd Session, (January 4, 1839), pp. 3, 4, and *Supplemental Report* of February 16, 1839, 25th Congress, 3rd Session, pp. 4 to 7, contain the Oregon Memorial of 1838, with the signatures of the Petitioners. The author is indebted to Dr. George P. Hammond, University of Southern California, for permission to reproduce the above foot notes. They appeared in a contribution which the writer prepared for publication in NEW SPAIN AND THE ANGLO-AMERICAN WEST, Historical Contributions presented to Herbert Eugene Bolton, 2 vols., Lancaster, Pa., 1932.

Some Important Effects of the Summer Fallow System of Farming on Soil Erosion in the Pacific Northwest[1]

W. A. ROCKIE[2]
State College of Washington

SUMMER fallowing, as it is generally interpreted today, consists of the practise of tilling a field during a growing season, but without a vegetative cover. This was first practised in the early days of agriculture to rest the land after its yields began to decrease. At that time it was more often "rested" without attention or cultivation. After a period of idle or rest years, the land would again show increased crop yields. The increased yields were generally accepted as the result of the rest. It was also learned that fallowing accomplished the storage of moisture from one year to another, so that by fallowing in alternate years, a reserve of soil moisture could be saved for the crop of the succeeding year. These effects of fallowing land are of a beneficial character and the summer fallow system has become an established agricultural practice in certain parts of many countries.

Summer fallow is not entirely beneficial, however, as studies in soil erosion are beginning to show. In portions of the states of Washington, Idaho, and Oregon, such as the Palouse region, which have 18 or more inches of precipitation per year (mostly during the winter), summer fallow appears to be the primary cause for destructive soil washing; while in the drier sandier sections lying to the westward (the Columbia Basin region) summer fallowing is a primary cause of soil drifting. Heavy textured summer fallow lands in any part of the region are especially subjected to erosion by dashing summer thunder showers, but are less subject to wind erosion than the sandier lands.

Winter Erosion in Palouse and in Similar Regions

Soil washing, which is so destructive to the better farm lands of eastern Washington, northern Idaho, and northern Oregon, is more destructive following a season of summer fallow than after any cropping condition with the possible exception of potatoes.

In 1930 and 1931, some determinations of soil moisture were made by the writer which indicated that the soil on fallow fields was nearly saturated at the end of the dry season in each of these years. Earlier work by Sievers and Holtz,[3] showed that the summer fallowed land was very moist throughout the entire soil section at the end of the summer season. It appeared impossible for it to absorb much of the precipitation which fell during the winter season following the summer fallow operations.

During 1932 numerous moisture determinations (Table No. 1) were made to substantiate general observations and the data which were already available from earlier work. These determinations showed that the entire soil section, excepting the upper four to six inches of the surface foot remained in a saturated or nearly satur-

[1]Published as Scientific Paper No. 226, College of Agriculture and Experiment Station, State College of Washington, and presented at the annual meeting of the Northwest Scientific Association, December 28-29, 1932, Spokane Washington.

[2]Superintendent, Pacific Northwest Soil Erosion Experiment Station, United States Department of Agriculture co-operating with the State College of Washington.

[3]Bulletins 166, 176, 189 and 206 of the Washington Agricultural Experiment Station.

ated condition during the entire fallow season. The loose mulch created by the rod weeder, the disk, the harrow or whatever implement was used to destroy the weed growth and to maintain the loose surface condition, was practically air-dry. The average moisture content after summer fallow, but before any autumn precipitation, was 15 per cent in the first foot, 21 per cent in the second foot, 21 per cent in the third foot, 23 per cent in the fourth foot, 22 per cent in the fifth foot, 22 per cent in the sixth foot, with an average content throughout the six-foot section of 21 per cent.

With the exception of land from which a potato crop was taken, all cropped land showed a very much reduced moisture content at the end of the crop season. These data are also given in Table No. 1.

Since the Palouse soil will hold only from 20 to 25 per cent of moisture, or occasionally as much as 25 to 35 per cent while water stands for extended periods on the surface, it is quite evident that the autumn rains will frequently be sufficient to completely saturate the fallowed surface soil so that much of the winter and spring precipitation is not absorbed but runs off. The cropped soil, on the other hand, is generally sufficiently low in moisture at the beginning of the fall rains that it can frequently absorb all of the winter's precipitation without runoff.

TABLE NO. 1

Soil Moisture Content at End of Dry Summer Season on Fallowed and on Variously Cropped Lands in 1932.

Land Use	No. of samples included as basis	First foot	Second foot	Third foot	Fourth foot	Fifth foot	Sixth foot	Six-foot section
Hard Fallow (untilled and unvegetated)	1	7.64	19.56	21.75	20.03	19.33	19.23	17.92
Summer fallow	9	15.29	21.82	21.52	23.13	22.25	22.71	21.10
Potatoes	4	12.12	20.40	20.19	23.53	26.18	28.77	21.86
Grass Sod	1	6.62	7.10	11.85	13.91	13.03	16.58	11.52
Peas & Sweet Clover (1st yr. mixed)	1	6.14	11.30	15.26	14.07	14.66	15.69	12.85
Alfalfa (1st yr. stand-	3	7.25	13.96	13.20	14.09	16.65	18.48	13.93
Spring Wheat	1	6.99	9.35	14.21	16.96	12.50	13.48	12.23
Winter Wheat	49	7.67	10.65	11.29	12.64	15.29	17.61	12.59

With the exception of land from which a potato crop was taken, all cropped land showed a very much reduced moisture content at the end of the crop season. These data are also given in Table No. 1.

Since the Palouse soil will hold only from 20 to 25 per cent of moisture, or rains that it can frequently absorb all of the winter's precipitation without runoff.

The summer fallow system in that part of the region having more than 18 inches of rainfall and extending from Spokane to Pendleton, via Pullman, Dayton and Walla Walla, appears to be a questionable practice. It certainly is not without objectionable features. It is definitely the cause of the loss as runoff of approximately one-fourth of the year's precipitation together with

about 40 tons of soil per acre following each fallow year. During the year when the land is cropped there usually is practically no runoff and hence no erosion. Where the precipitation is from 10 to 15 inches, and within the region of these heavier soils, the soil-washing problem is much less crucial.

Soil Drifting in the Drier Lands

On the sandier lands of central Washington, the practice of summer fallowing was first done primarily to conserve moisture. It has also proven beneficial[4] there from the nitrification standpoint. From these reasons the practice has tended to maintain the level of crop production.

At the same time that these benefits were gained the soil, which, when first broken was filled with decayed and undecayed vegetable matter accumulated during unnumbered past centuries, has with each year of cultivation been losing a part of this accumulation. This has been caused by mechanically breaking the particles into smaller and smaller bits as a result of tillage. The loss of organic matter occurred partiially from removal by wind and partly by oxidation during the characteristically long dry season. The result has been a constantly decreasing organic matter content of these soils, and therefore, a less cohesive soil. The winds which characterize the region, while no different than during the recent decades, therefore cause more soil drifting than formerly.

While covered by vegetation, these soils are still relatively safe against "blowing" but when in the loose fallow state, the soil offers no effective resistance to the wind. Careful tillage of the right kind minimizes, but not always prevents soil drifting. Even a gentle 10 to 15 mile breeze causes this soil to drift more or less, while every windy day is a serious menace to this entire region. The season of the year when the windy days occur matters little unless the ground is frozen. In the frozen state, the soil does not drift so much, but under almost any other circumstance, except while rain falls, a windy day drifts this sandy loam soil. Even if the soil is wet, a few moments of wind dries the surface sufficiently that it will drift along the land surface. The days in the Columbia Basin region can be divided, from this standpoint, into four groups, (1) still days when the soil does not move, (2) days with a light wind up to 10 or 15 miles per hour when all unvegetated (and some vegetated) fields "smoke"[5], (3) windy days when the sky is murky with the moving soil, and (4) very windy days when because of wind-driven soil there is no sky and all of man's activities are practically at a standstill. Most of the days of the year belong to the first group, many to the second, scores to the third, with only occasional days in the fourth group.

This drifting is largely resultant from the effects of tillage during the past 35 years. Summer fallowing on lands in this condition will undoubtedly make the situation progressively worse.

Erosion From Summer Rains

The heavy local summer showers which especially characterize certain sections within the Pacific Northwest, and which history indicates may occur in any part of the entire region, and more especially east of the Cascade Range, also represents a most serious threat to summer fallowed lands of heavy texture. One particular storm previously described by the writer[6] is only typical of many such storms which are of actual record. These rains are

[4]Bulletins 138 and 189 of the Washington Agricultural Experiment Station.

[5]Local term for soil drifting along the land surface but not rising many feet from the ground.

[6]Bulletin No. 271 of the Washington Agricultural Experiment Station.

much more destructive over a short period of time than any other common type of erosion, and it is only because of the relatively infrequent occurrence of such storms in any given locality, that any arable soil remains in these areas.

Summary

These three types of erosion, two caused by water and one by wind have developed and are becoming progressively more severe with each passing year because of the decreasing resistance of the soil itself. Each one of these three types is primarily and chiefly serious because of the present regional practice of summer fallowing.

These impoverishing types of erosion would be largely controlled if the summer fallow system were discarded.

The elimination of the summer fallow practice from the Palouse region especially in its drier sections would necessitate revolutionizing the agriculture of that region. Where, and with what cropping, livestock and marketing practices should the present wheat-fallow-combine practice be gradually replaced? *What is* the best use for the eroding farm lands of the Palouse country?

To eliminate the summer fallow from the dry and sandy lands of the Columbia Basin region would necessitate that much of the land no longer be sown to grain. It would practically require the return of this land to grass. Is this the proper land use for much of this semi-arid district?

These detailed and specific problems of different localities, existing under different climates, on different soils, occupying country of varying topography, and with different crop and livestock possibilities, are the heart and the core of one of the greatest agricultural and economic needs in the Pacific Northwest today. It is *the* problem with respect to the physical side of land use. This need is proper land utilization from the coordinated viewpoint of the nation, the state, the community and the individual.

Lignin, one of the chief constituents of wood, and as yet one of the most puzzling to chemists and industrialists, has been made artificially in the U. S. Forest Products Laboratory at Madison, Wisconsin, by Drs. L. F. Hawley and E. E. Harris. This research followed pioneer work done previously by Dr. Hawley with Dr. Jan Wiertelak. The results have been reported to the American Chemical Society through its official journal. Lignin was made in sealed tubes, by heating cellulose, the most useful constituent of wood, at a temperature of 135 degrees Centigrade (307 degrees Fahrenheit) for periods up to eight days in length. The artificial lignin thus obtained gave the same reactions as the natural lignin to various chemical tests. It is not expected that this artificial lignin will be of immediate direct commercial importance. But the discovery of Drs. Hawley and Harris will eventually be of economic value, because it leads to a better knowledge of what lignin is and will do, and this knowledge in turn is of use either in getting rid of it or even in finding a profitable occupation for it.—(Science, 1932)

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1000 Washington Ave., Brooklyn, N. Y., U. S. A.

MOSCOW PUBLISHING CO.

Printers

MOSCOW, IDAHO

NORTHWEST SCIENCE

SMITHSONIAN INSTITUTION
JUN 13 1933
NATIONAL MUSEUM

JUNE
1933
Vol. VII Number 2

573
7

Published by
The
Northwest Scientific Association
Single Copy Thirty-five Cents

NORTHWEST SCIENCE

A scientific journal published quarterly by the Northwest Scientific Association and devoted to the dissemination and promulgation of scientific effort in the Pacific Northwest

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NORTHWEST SCIENCE

Entered as second class matter April 5, 1927, at the Post-Office at Cheney, Washington. Office of Publication, Cheney, Wash.

Published quarterly at a subscription price of $1.00 per year, which includes the membership dues of the Association. Non members $1.00 per year. Vols. I (1927), II (1928), III (1929), IV (1930), V (1931), complete, each $1.25.

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Pages	2	4	8	12
100 copies without cover	$2.50	3.00	5.45	5.95
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Printing of plates extra, at actual cost

NORTHWEST SCIENCE

VOL. VII JUNE, 1933 No. 2

The Association is not responsible, as a body, for the facts and opinions advanced in the papers published by it.

EDITORIAL

NOW that the duties and objectives of the newly elected trustees of the Northwest Scientific Association have been clearly defined and steps taken to attain the objectives which have been set, it is the duty of each member of the Association to familiarize himself with the details of the project.

At no time in the history of the Association has there been a greater need for unity. There is considerable evidence to indicate that a certain reaction toward education in general and research in particular is taking place under the stresses of our present economic difficulties. In many parts of our land we, as people, are permitting the closing of schools and are allowing our teachers to drift into the ranks of the unemployed when we should, as never before, urge greater efficiency in education and endeavor to keep the teaching forces employed. If we fail in this we shall fail miserably in protecting ourselves and the coming generation against an irrepairable loss. Whether or not our educational systems will stand the test of reaction rests largely with those who are a part of these systems as well as with those who direct them. Unity of action is essential.

As members of the Association we have a common project—one to which we can all contribute in time and effort, and one in which we can all share the pride of accomplishment. The project as outlined by the trustees, has as its first objective a survey of the research work completed and under way in the region covered by the Association. This survey will very probably evolve into a list of those research problems of the region which are in greatest need of solution at the present time. The problems should cover all the basic industrial activities of the region such as agriculture, mining, forestry, manufacturies and public utilities, and it should also cover studies of fish and game, water power and city water supplies. The second objective includes three steps and covers, first, the selection of vital problems; second, a search for the individual researcher capable of handling the problems; and third, the designation of a suitable institution for the carrying on of the research work. The third objective, which might more properly come first, is the raising, by various means, of a sufficient fund to finance a small number of qualified workers selected to carry on the investigative work designated.

The project is a highly commendable one and every encouragement and assistance should be given the trustees and the special committees entrusted with the work so that a beginning may be made this year. The threatened curtailment of research work in certain branches of the federal government should make us realize that we are facing a crisis and should spur us on to a more active support of the investigative programs of the region.

Geologic Climates of The Inland Empire[1]

By

Otis W. Freeman

State Normal School, Cheney, Washington

THE possible causes and effects of rainfall cycles and changes of climate attract the interest of both climatologists and geologists. This paper will discuss some relationship between climate and geology.

The evidence indicating past climates consists of certain deposits, the results of surface erosion, and of both plant and animal fossils. Deposits made by glaciers in the Inland Empire provide definite proof that at least three glacial epochs occurred during the Pleistocene separated by mild interglacial epochs, while climate much like the present. The evidence from fossil plants and animals is not so certain, and in this paper a conservative view is taken regarding the conclusions drawn from prehistoric flora and fauna.

In evaluating fossils as evidence of prehistoric climate it is necessary to assume that plants and animals similar to present species lived under climatic conditions in the past similar to those where they live at present. In drawing conclusions from fossil evidence there lies the possibility of error. For example, corals grow only in water whose temperature does not fall below 65° F. The author has gathered corals from Paleozoic marine limestone outcropping in mountains of central Montana and corals of approximately the same age have been found in northeastern Washington and the Blue Mountains. Therefore shall we conclude that the climate of Montana and the Inland Empire was once truly tropical like a South Sea Island? The most northerly place in the Atlantic today that reef forming corals grow is the Bermuda Islands in latitude 32° North, a location in the midst of the Gulf Stream. Were islands found farther along in the Gulf Stream the temperature conditions would permit the growth of coral several hundred miles north of Bermuda. Species of coral grow today in the Mediterranean in almost the latitude of Washington, although these are not reef-forming. The bulk of the water of the Gulf Stream comes from the South Atlantic Drift and is deflected northward by the angle of Cape Sao Roque. Suppose the Isthmus of Panama to be a strait or suppose a vast epicontinental sea to extend across North America from the present Caribbean region to the Arctic as happened as late as the Cretaceous period; then the warm Gulf Stream would sweep northward across the present western United States and might easily permit the growth of coral farther north than the Canadian line. To account for geologically ancient mild climates, it would therefore not be necessary to postulate a change—a change in insolation, in the content of carbon bioxide and dust in the air, of migrating poles, of floating continents, or the convectional hypothesis of the welling up in high latitudes of warm salty water that is supposed to have sunk in the zone of trade winds from rapid evaporation of water there. This last hypothesis is attractive and would result in world wide uniform temperatures. According to this suggestion the present cold temperatures of ocean depths is a hang-

[1]Presented at the Pullman meeting of the American Meteorological Society, June, 1932.

over of the glacial period. During the Paleozoic era, cool and light (because less salty) surface water returned to the equator to replace the warm but heavy (because more salty) water that sank.

The climate of the Inland Empire during the Cenozoic era until the Pleistocene appears to have been rainier with less cold in the winter than at the present time; this can be accounted for by the upbuilding of the Cascade Mountains without appeal to changes in the location of wind belts and ocean currents or the amount of insolation and other hypothetical factors.

At the close of the Cretaceous period and beginning of the Cenozoic era the Rocky Mountains were uplifted together with associated ranges and plateaus to the westward. The resulting greater extremes of climate helped stimulate the evolution of mammals. The huge dinosaurs of the Mesozoic era all perished probably because they were too specialized to endure changing conditions. By the Eocene period plants predominately belonged to modern genera and even some species still survive. During the Cenozoic era there was a progressive increase in numbers of herbaceous plants which are adapted to severe winters since they die down to the ground each year or start anew annually from seed. This indicates a change from the mild temperature ranges of the Cretaceous period. Of course, part of the absence of herbaceous plants early in the Eocene may result from the greater difficulty of preservation of plants without woody structures. Herbs appear to have descended from woody plants.

An abundant Eocene flora that numbers over 300 species has been described from the Puget Sound region. The Olympic Mountains were already in existence in the Eocene and formed an island off the coast, but the Cascades were not yet built up and the Puget flora extended east of the present Cascades and north to southeastern Alaska. As mountains rose in the north sediment accumulated in the Puget Basin which slowly sank under the load until the beds became two miles thick. Considerable lignite coal proves the presence of extensive swamps and marshes. Elms, persimmons and magnolias were common in the Puget flora of the Eocene, but do not exist in forests there at the present time. Fan-palms were fairly common with leaves up to four or five feet in diameter. Fresh water lakes and peat swamps existed in Kittitas county and adjoining areas east of the Cascades which account for the coal there. East into Montana poplar was very common and the presence of alder, chestnut, hazelnut, maple, elm, magnolia, beech, etc., indicates wetter conditions than the present. The flora of Denver, Colorado, contains numerous fan-palms which decreases in Montana to only one species and that one uncommon, suggesting that the temperature limit for palms was near. Probably winter temperatures in the Eocene were higher than now, for the west winds from the Pacific had no barrier to cross, thus bringing a mild rainy climate far inland. The presence of palms does not necessarily indicate tropical conditions inasmuch as the palmetto grows in North Carolina and palms grow well in north central California where 10-15° F. of frost have been known.

During the Oligocene epoch ancestral horses and camels continued to evolve in western North America, suggesting the presence of extensive grasslands and possibly increasing aridity. Plant fossils of this period have not been found in the United States but those of Germany which include pines, spruces, sequoias, oaks, beeches, and maples, indicate a temperate flora. Similarities in animal life between the continents suggest that the climates

were also similar. In the John Day Basin of Oregon about 1650 feet of volcanic tuffs and other terrestial deposits chiefly wind blown, have been classified as Oligocene. The fossils are of running animals suited for life in an open country, and comprise animals such as camels, oreodonts, horses, cats, and dogs. There was a great diminution in numbers of browsing mammals which likewise suggests herbs and grass rather than forests.

The Miocene is probably the most important geologic period to a resident of the Inland Empire because of the vast outpourings of basaltic lava that built up the Columbia Plateau. The laval flows dammed streams to form lakes while crustal movements formed other lake basins. Volcanic ash, mud and sand washed into the lakes preserved leaves and other plant remains quite perfectly. Animal fossils are rare in the lake beds. Lava flows also overwhelmed forest trees knocking them down and covering the trunks with the hot but solid lava on the bottom and front of advancing flows. Most trees were burned but numerous specimens were only charred and some hardly affected. Some charred wood can be found today between flows, perfectly preserved for over a million years. Most of the wood has been petrified by replacement of the wood by quartz deposited from ground water. Petrified logs nearly 100 feet long and tree casts or molds several feet in diameter indicate an age of several centuries for some of the trees. A few fragmentary bones of mammals have been found between lava flows on the east wall of Grand Coulee. Thousands of years may have elapsed between successive lava flows. The size of the trees indicates a much rainier climate than the present. Rings of growth in the petrified wood show seasonal changes of temperature like the present time. Also some specimens show series of wide and narrow rings of growth which suggest that cycles of wet and dry years occurred then as they do now. Perhaps a future tree ring reader will be able to correlate the time of lava flows here with the petrified forests of the Southwest on the basis of such rings of growth.

The plant fossils of the Miocene have been studied by F. H. Knowlton, E. W. Berry and others. Berry lists 152 species from the Latah formation near Spokane and over 200 species have been recognized from the Miocene lake beds of the whole Inland Empire. Among the trees identified are sequoia, pines, maples, sycamores, oaks, wild plum, hickory, laurels, willows, beeches, birches, magnolia, figs, persimmon, sassafras, ginkgo, poplars, elms, tulip trees, bald cypress, chestnut, and incense cedar. Berry states that 39 genera out of 75 in the Latah flora are not now represented in Washington. The Latah flora would necessitate a temperate climate and well distributed rainfall of at least 30-40 inches annually, like the northeastern part of the United States. Since the beds at Spokane and the Grand Coulee seem to have been deposited in late Miocene it suggests that the whole Miocene period was relatively rainy without progressive desiccation of the country, as generally stated in textbooks. The Cascades began to be built up in the Miocene and the process continued during the Pliocene down almost to the present time. This Cascade uplift shut off the rain-bringing winds from the Pacific ocean and resulted in progressive lessening of rainfall and greater extremes of temperature which must have resulted in the extermination of numerous plant species previous to the glacial period.

The most profound changes of climate in the Northwest took place during the Pleistocene.

In the Puget Sound region J. Harlen Bretz recognized three epochs that he named Admiralty (glacial), Puyallup (interglacial) and Vashon (glacial).

Edwin T. Hodge found evidence for five epochs of climatic change in the Cascade Mountains of Oregon from the late Pliocene to the present, namely; a late Pliocene epoch of erosion and small precipitation, the Cascadian epoch of glaciation, the Willamettian epoch of aggradation and small precipitation, the Jeffersonian epoch of glaciation and great precipitation and the recent or post-glacial period of aggradation and small precipitation. The proof of these changes are found in: glacial and stream work, deposits and profiles of streams. coastal deposits, deposits adjacent to the Columbia, John Day and Deschutes rivers and in fossil lake sands and silts.

Three advances of glaciers are known in eastern Washington separated by epochs of mild temperature. These continental glaciers all came from the highlands to the north and northeast of the Columbia Plateau. The earliest glacier is called the Cheney. The material left by this glacier so far identified consists wholly of ground moraine only 2 to 5 feet thick both underlain and overlain by loess, a dust deposit from the wind. The moraine consists almost wholly of foreign rocks such as gneiss, granite, argillite, schist and quartzite from the Okanogan Highlands and Canada, with very few boulders of basalt, the surface rock of the Columbia Plateau, over which the glacier advanced for 20 or 30 miles. Evidently the Cheney glacier did little work of local erosion. No outwash gravel has been found associated with Cheney drift and it seems probable that the ice disappeared by evaporation rather than melting. The occurrence of loess above and below the drift also suggests an arid climate. The Cheney drift is deeply decayed. Schist and the few basalt pepples crumble at a touch. The Cheney corresponds to one of the earliest glacial epochs of the Middle West and is possibly Kansan or Illinoisan in age.

The second advance of the continental glacier has been named the Spoknae. This was probably the equivalent of the Illinoisan, if the Cheney is Kansan, or of the Iowan glacial epoch of the Middle West if the Cheney is Illinoian. Lobes of the Spokane glacier crossed the Spokane River to Four Lakes and Medical Lake and over the Columbia valley on the Waterville Plateau. This glacier appears to have melted so very rapidly as to have almost literally dissolved into a tremendous flood. This is the Spokane Flood of J. Harlen Bretz who believes that the peculiar erosion forms, called the canneled Scablands of eastern Washington, resulted from the effects of this flood. Much of the flood water probably came from Lake Missoula by the breaking of an ice dam that had formed the lake. The Spokane moraine contains more basalt erratics than the Cheney and the material is not so much weathered as the Cheney drift.

After an interval there was a third advance of the ice which is called the Wisconsin and is correlated with the last glacial epoch of the East.

Since the disappearance of this ice the climate of the Inland Empire has probably continued much like that of the present time. The Cascade Mountain uplift produced the profound differences in rainfall and temperature between the coastal climate and that of the Columbia Plateau. The Rocky Mountains at the same time protected the region to the west against the extremes of winter cold that are suffered by the Great Plains. The relief and

favorable exposure to rain-bringing winds like the relation of the Palouse country to moist masses of air that pass through the Columbia Gorge as compared with conditions in the rain shadow of the Cascades in the Columbia Basin desert result in great local differences in rainfall in the Inland Empire. Protection from frost and the effects of the most severe cold waves of winter by relief features influences location of orchards and other types of land utilization. Various climatic factors which affect the native animals, natural vegetation as well as human use of the Inland Empire today, were equally effective in the geologic past and greatly influenced the evolution of life.

The fossils, deposits, and erosion forms tell a dramatic story and one that is worthy of elaboration and interpretation.

Itinerary of Excursion C-2, 16th International Geological Congress, August 10-20, 1933

August 10—Klamath Falls to Crater Lake by motor.

August 11—Two-day trip from Eugene, Oregon, across Cascade Mountains, John Day Basin and Columbia River Plateau to Wishram, Wash., by motor, R. W. Chaney, guide. Extensive continental deposits of Tertiary age with animal and plant remains.

August 14-15—From Coulee City to Spokane, Washington, by motor through the Scablands, J. H. Bretz, guide. Depositional and erosional effects of continental glaciation, including the floods produced by melting of ice sheet.

August 16—Crossing Rocky Mountain Province.

August 17—Butte, Montana; E. S. Perry, guide. Underground and surface geology of the Butte district; optional visit to smelter.

August 18-20—Six-day trip by motor through Yellowstone National Park, Shoshone National Forest and Bighorn Mountains, Wyoming, and Beartooth and Pryor Mountains, Montana; R. M. Field, W. T. Thom, Jr., N. M. Fenneman, D. W. Johnson, R. T. Chamberlain, W. H. Bucher, E. Dorf, E. S. Perry, and G. L. Jepsen, guides. Tertiary volcanic and erosional history of Yellowstone Park hot springs and Geyser basins. From Yellowstone Park to Cody, Wyoming, for further studies.

R. M. Field, of Princeton University in charge.

For further information address International Geological Congress, Chamber of Commerce Building, 1615 H Street NW, Washington, D. C.

Some Features of the Idaho Batholith[1]

By Clyde P. Ross
U. S. Geological Survey

The Idaho batholith intruded Belt strata over much or all of its central portion and Paleozoic beds on both sides. Considerable areas of it are covered by Tertiary and later strata which rest on its eroded surface.

It is believed that the area now occupied by the batholith is a positive element in the earth's crust which has for the most part been above sea level since the end of the Algonkian. During much or all of the Paleozoic the western shore of the interior or Cordilleran sea coincided in position approximately with the eastern border of the present exposure of the batholith. The greatest geosynclinal accumulations in the Paleozoic were just east of the present Idaho batholith while comparable thicknesses of Mesozoic beds were deposited in a trough 150 miles or so farther east.

The Idaho batholith is composed mainly of somewhat calcic quartz monzonite. In general it is believed to have been intruded essentially as a unit rather than as an aggregate of discrete bodies such as compose the batholith of the Sierra Nevada.

In the outer portions of the batholith wherever strata of probable Belt age are preserved there is an irregular shell of gneiss, commonly dioritic, which, wherever the relations can be determined, is older than the quartz monzonite. The dioritic gneiss commonly includes and is associated with Belt rocks more or less thoroughly injected and replaced by the igneous material. It is noteworthy that Paleozoic rocks on the flanks were metamorphosed but very little injected as a result of the intrusion.

It appears that the Idaho batholith had, over much of its extent, a nearly flat roof and comparatively steep, outward,sloping sides, with a transverse depression in the roof along the westward flowing section of the Salmon River between Shoup and Riggins. The roof has been less deeply and completely cut into in northcentral than in southcentral Idaho, but even in the latter region erosion has not yet penetrated so very far below the original roof.

The Belt strata are flexed, metamorphosed and locally broken by thrust faults, in part possibly pre-Permian. In remnants of such rocks in the batholithic roof there is commonly conspicuously less close folding than in the Paleozoic rocks on the eastern flank. The latter are characterized by closely compressed overturned, pinched and broken folds. Overturning and overthrusting are in general toward the northeast. There is evidence that the intrusion of satellitic stocks was accompanied by deformation and fracturing. Both the stocks and the main batholith came into their present positions subsequent to at least much of the close folding but possibly before thrust faulting had ceased. The anticline immediately east of the east flank of the main batholith conforms closely in trend to the sinuosities of the igneous contact.

It appears that the intrusion of the Idaho batholith played a major role in the diastrophism of the region. Possibly the long continued upward tendency of the earth block now contain-

[1]Abstract of paper presented at the annual meeting of the Northwest Scientific Association, Dec. 28-29, 1932, Spokane, Washingon. Published by permission of the Director, U. S. Geological Survey and the Director, Idaho Bureau of Mines and Geology.

ing it is connected with deep-seated hydrostatic adjustments of magma such as are required by Keith's concept of batholithic intrusions as one of the immediate causes of mountain building.

It is thought that the Idaho batholith corresponds more closely in age with the intrusions of post-Triassic and pre-Upper Cretaceous age to the west and north than to such apparently younger intrusions as the Boulder batholith farther east. There is evidence pointing to an eastward migration of both intrusive igneous activity and orogenic movement.

Oregon Batholiths[1]

By E. T. Hodge

Oregon State College

The writer[2] has in connection with other forms of field study observed batholithic phenomena in the Northwest including Alaska, British Columbia, Yukon and Washington since 1916, and since 1920 has been able to study the exceptional volcanic field of Oregon. The fundamental importance of batholithic activity as a causal agent in the production, not only of the igneous and igneous-derived rocks, but also of most of the other geological phenomena in the Northwest, was, consequently, recognized early in his studies. For this reason batholithic history has been an object of constant investigation. Because of the wide diversity in results and the complexity of the subject, the writer has never felt warranted in presenting any definite conclusions. This report on Oregon batholiths is only preliminary in character.

Oregon is one of the most remarkable igneous terranes in the World because of the duration, persistence and intensity of its magmatic activity. Geologic mapping of Oregon shows that 85 per cent of all known rocks and 75 per cent of the Tertiary rocks by volume are of igneous origin. Igneous activity took place on a large or small scale in the pre-Cambrian, Siluro-Devonian, Mississippian, Permian, Triassic, Jurassic, Cretaceous, and in each of the Tertiary periods. No Cambrian or Ordovician formations are known in Oregon.

One or more erupting or intruding magmas were continuously active throughout geologic time in Oregon except as follows: probably in Cambro-Ordovician periods, perhaps during mid-Carboniferous time, again in mid-Jurassic time, until the close of the Cretaceous, between the Eocene and the upper Oligocene and during the lower and middle Pliocene.

The intensity of activity was not so great in the pre-Cambrian, Siluro-Devonian, and Mississippian; it was more intense in Permian, Triassic, and early Jurassic time. It reached a climax at the close of the Jurassic; reached another but lesser climax at the close of the Cretaceous. The Tertiary in Eocene, upper Miocene, and late Pliocene and Pleistocene have been more active than all other epochs, except the last of the Jurassic. Few

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[1]Presented at the annual meeting of the Northwest Scientific Association, Dec. 28-29, 1932, Spokane, Washington.

[2]The material of this paper was presented as a Report to the Committee on Batholiths of the National Research Council early in 1931 and a discussion of it appears in their report of that year.

other regions of Tertiary formations contain such a large volume of igneous rock and indicate such a dominance of igneous activity over all other forms of geologic activity.

The relationship of batholithic expression to diastrophism may be summarized as follows: No igneous activity followed the diastrophism at the close of the pre-Cambrian, nor at the end of the Siluro-Devonian, nor at the close of the Carboniferous. Though great diastrophism occurred at the very close of the Permian, yet the vulcanism of the Triassic was during and not at its close; volcanism preceded diastrophism by practically a whole geologic period. The vulcanism of the Triassic was during and not at the close when diastrophism was active. Igneous activity began in the early Jurassic and reached its dominance at the close of the Jurassic at which latter time it was associated with diastrophism. During Cretaceous time diastrophism and igneous activity were associated. The Tertiary diastrophism was active about mid-way between periods of great igneous activity, but not with them. Hence, only in two cases is the evidence conclusive that batholithic movement has been associated with diastrophism.

The Coriba[3] formation resulted from the largest single surface expression of volcanic eruptivity in the world and is the principal rock unit in the State of Oregon. In the State of Oregon it is composed of approximately 150,000 cubic miles of basalt. This formation, the writer believes, was deformed by sagging over an extravisated area rather than by diastrophic forces of compression or extension as usually defined. Investigations[4] indicate that Oregon lies in a non-seismic area and an explanation is suggested that a liquid magma still exists beneath Oregon and that many of the shock producing surfaces are cushioned by igneous rock.

The longest erosion interval between diastrophic or volcanic activity was in the Cambro-Ordovician times. Since that time these erosion intervals have grown shorter and shorter, and in the Tertiary were of very small duration; the longest was between the Eocene and the Oligocene. The late Pliocene, Pleistocene, and Recent volcanic activities were not separated by any period of erosion or diastrophism but have been of a continuous nature. There is evidence[5] that the John Day Formation is upper Oligocene and lower Miocene in age, and is part of and almost continuous as to time of deposition with the Coriba formation. This conclusion increases the hiatus between the Eocene and upper Oligocene and decreases it between the Oligocene and Miocene.

Five stages of glaciation are known in Oregon and each was co-existant with active volcanoes on Mount Hood. Glaciers frequently were buried by lava flows and cooling lava flows quickly became repositories of newly formed glaciers.[6]

The continuity of igneous activity, the lack of relationship of diastrophism to five stages of eruption and the decreasing hiatus between stages of igneous activity suggest a common batholithic source. On the other hand the wide difference between the mineral composition of intrusive and extrusive igneous rocks favors no common batholithic origin. A few check cases exist, for example, the rhyolitic Oligocene was succeeded by the ba-

[3]A mnemonic expression proposed for the cumbersome name Columbia River Basalt formation.
[4]Hodge, E. T., Earthquake Hazards of the Pacific Coast, 53d Annual meeting of the Fire Underwriter's Association of the Pacific, 1929.
[5]Hodge, E. T., New Evidence of the Age of the John Day Formation, Bulletin Geological Society of America 43, 695-702, 1932.
[6]Hodge, E. T., Late Tertiary Climatic Changes in Oregon—Monthly Weather Rev. 58, 4-5-411, Oct., 1930.

saltic Miocene with no erosional interval between. A better example is the complex Clarno (Eocene) formation which is composed of many diverse types of igneous rocks that were injected and extruded within a comparatively short geologic period of time. The Clarno formation is evidence that one magma may give forth many diverse products. We suspect, therefore, that one large batholith has been active beneath Oregon from pre-Cambrian to the Recent; a speculation that is novel, startling, and, if true, exceedingly significant.

In this brief summary the writer cannot state all the evidence of diverse differentiation shown by each geological period. The rocks that occur belong to well-known types such as biotite granite, hornblende granite, albite granite, rhyolite, tonalite, alaskite, granodiorite, trachyte, quartz diorite, diorite, andesite, monzonite, diabase, hypersthene basalt, hornblende basalt, andesite-basalt, augite basalt, hawaiite, dacite, gabbro, perioditite, saxonite, pyroxenite, olivene-basalt, and a great variety of glass.

Dr. Frank F. Grout,[7] chairman of the National Research Council's Committee on Batholith Problems says:

"Data in Oregon suggest a large batholith active in the region *continuously from pre-Cambrian to Recent time*. This needs a check and critical review, for while the idea is very stimulating, and, if true, very significant, it upsets a large number of speculations and assumptions in areas like the Canadian Shield. Correlations over wide areas have been based on the idea that in the Shield there have been two and only two, rather restricted periods of batholithic invasion. Another suggestion of prolonged batholithic activity in a region somewhat similar to that of Hodge may be derived from the observations of K. C. Heald on the structures of oil domes, indicating a great number of successive uplifts, not due to lateral compression;—say from Ordovicion through Permian, or from Carboniferous through the Tertiary. In a district like that of the Jackson Dome in Mississippi, where the center of the dome covers an igneous plug the upward movements suggest batholithic activity through a prolonged period."

The small size of the batholiths and the evidence of exceptionally free extrusion may explain the lack of accompanying diastrophism in Oregon as compared to other regions where extrusion was restrained.

The metallic mineralization in Oregon is the result of the same magmatic epochs as that in the rest of the American Northwest. There are, however, some characteristics typical of Oregon which will be briefly listed below.

The late Jurassic intruded rocks are of intermediate types such as quartz monzonite and granodiorite. They formed small, peripheral bosses on what was probably a great batholithic mass. These produced in southwestern Oregon and northeastern Oregon a mineralization of quartz veins and auriferous sulphides, in shear zones and simple veins. The same epoch produced an extensive and wide-spread mineralization of copper deposits classifiable under eight different types. In addition, deposits of chromite and of nickel were formed.

The post-Cretaceous batholith and its intrusions were apparently without mineralizing influence. In the Eocene many small intrusions of dikes, sills, laccoliths, and volcanic necks produced a minor mineralization in eastern Oregon. In the late Pliocene small, fine-grained masses of quartz-diorite, monzonite, alaskite, and granite occur in

[7]Committee Report, April 23, 1932, p. 3-4.

a line of wide-spread fractured areas of argentiferous lead, copper, zinc, and auriferous iron sulphide in a calcite and quartz gangue.

Finally, in the early Pleistocene intrusive rocks, mostly as feeding dikes, produced deposits of cinnabar in a line along the west side of the Cascade Mountains, in the Ochocos and in southeastern Oregon.

In addition to the intrusive rocks producing mineralization, other intrusive rocks of a batholithic character occur such as Permian gabbros and diorites; Triassic peridotites and pyroxenites; Jurassic granodiorites, granites, gabbros, pyroxenites, saxonites, albite-granites, tonalites, quartz-diorites, and diorites; late Cretaceous granites; Eocene basalt porphyrys, quartz diorites, diorites, and granites; Pliocene and Pleistocene volcanic necks and feeding dikes of andesites, trachytes, and rhyolites. The largest intrusive batholith is the Siskiyou batholith of late Jurassic time.

Dikes, sills, and stocks are fairly common in the Palaeozoic and Mesozoic, but are rare in the Tertiary. None of the dikes of the Tertiary are large and only two occurrences of feeding dikes in the Coriba are known. Most of the Tertiary rock appears to have been central eruptions and many central eruptive vents have been found in the Eocene, Pliocene, and Pleistocene.

Explosive vulcanism producing rhyolitic, andesitic, basaltic, trachytic, and pyroclastic formations in the pre-Cambrian, Permian, Triassic, Jurassic, and all of the Tertiary. The John Day formation (upper Oligocene and lower Miocene) is the most widespread and thickest of the pyroclastic formations.

The proximity of the many batholiths or of a single batholith to the surface, and the character of the differentiated and expelled material, is shown by listing extruded and extrusive rock as successively formed down through the geologic periods. Contrary to the experience in many parts of the world there has been no regular succession. Within periods, and from period to period, the flows have varied from extreme persilic to very subsilic. Except for the olivine-bearing rocks, no under-saturated rocks such as the felspathoid-bearing have been produced. In the Tertiary, we find the greatest variation. Olivine basalt and silica-rich rhyolites and intermediate types occurred in rapid and irregular succession. In the Clarno the rhyolitic ashes of the John Day were followed immediately by the hawaiite rocks of the Columbia River basalt. The olivine basalt of the late Pliocene was succeeded immediately by andesites and during the Pleistocene and Recent, andesite, basalts, and obsidians occurred without any definite evidence of apparent rule or order of succession. The olivine basalts are the youngest lavas known in Oregon and they cover large areas. They occur within a few miles of Recent flows of obsidian and trachytic pitchstones.

The petrography of Oregon should furnish much data that may be used as a means of testing a number of theories of batholithic history and performance. As a first step in this study, the writer has just completed the geologic mapping in detail of 400 townships in north-central Oregon including the northern part of the Cascade Mountains.[8] The rocks of this region are nearly all Tertiary in age and are now in the process of investigation.

The solution of the batholithic problem in Oregon presents many difficulties. Oregon is far behind all other

[8]Hodge, E. T., Geologic Map of North Central Oregon, Univ. of Oregon Pub., Vol. 1, No. 5, February, 1932.

states in her topographic mapping program. Many geologists have visited Oregon, written valuable papers and helped swell the Oregon bibliography[9] but only Diller and Hodge have produced together maps covering a little over one-tenth of the state. Sampling of rocks has been erratic and scattered. Igneous contacts in western Oregon are exceedingly difficult to follow. The greater part of the volume of igneous rocks is glass and felsite that require a thin section for nearly every specimen. Even thin sections must be supplemented by microchemical and staining tests for accurate determination of their composition. Barely a dozen chemical analyses of igneous rocks have been made to date.

For these reasons many generalizations occur in the igneous literature about Oregon petrography that are not altogether correct. The laboring time in life is short and igneous petrography is, perhaps more than any other phase of Geology, the most difficult and time-consuming of all. The writer since 1924 has been directing a systematic mapping, sampling, and study of the igneous rocks of Oregon and is not ready yet to publish his first formal paper. Nevertheless, only by this method can progress toward a solution of the problem be made.

[9]Dixon, Dorothy, Bibliography of Oregon Geology, Univ. of Oregon Pub., Vol. No. 1, June, 1926. Hodge, E. T., Progress in Oregon Geology Since 1925. Northwest Science 6, 44-53, June, 1932.

Interpolation Of Wave-Lengths In Spectrograms[1]

GEORGE L. SHUE

Montana School of Mines

THE quartz spectograph is a splendid type of instrument for ultraviolet spectroscopy. However the determination of wave-lengths with a prism spectrograph presents a serious difficulty. The wave-length is a function of the index of refraction of the prism, of the angle of the prism, and of the angle of incidence of the light. Of these quantities the index of refraction is not perfectly known for all wave-lengths. It is observed to range somewhat in different prisms of the same material. Several empirical formulae have been devised for use in interpolating wave-lengths when a few known wave-lengths are available. This paper presents another interpolation formula.

The commonly used formula is the one by Hartman ($\lambda = \lambda_0 + \frac{C}{d - d_0}$). In it λ is the wave-length sought, d is the distance of the line of wave-length λ from a reference point, and d_0, C, and λ_0 are constants to be determined. Three lines of known wave-length are required in order to compute the constants. If these known wave-lengths are near in value to the wave-length sought an accurate determination of the wave-length is obtained. The computation of the constants is very tedious as one must solve three simultaneous equations. Since the Hartman

[1]Presented at the annual meeting of the Northwest Scientific Association, December 28-29, 1932, Spokane, Washington,

formula involves three known wave-lengths it is a form of three point interpolation.

The formula presented in this paper is a modification of Ampere's interpolation formula. The constants are easily obtained as all necessary multiplications can be done with a slide rule. In the spectrum known wave-lengths do not occur at regular intervals. This prevents the use of the simpler interpolation formulae. Three known wave-lengths are required and they should be in the same region of the spectrum as the wave-length sought. The middle value of the three should be nearest to the unknown line. (This is also true if Hartman's formula is to be used.) A difference table is used to simplify the work of computing the constants.

Formula

$$\lambda = \lambda_1 + (d - d_1)\frac{\lambda_1 - \lambda_0}{d_1 - d_0} + (d - d_1)(d - d_0)\frac{\frac{\lambda_2 - \lambda_1}{d_2 - d_1} - \frac{\lambda_1 - \lambda_0}{d_1 - d_0}}{d_2 - d_0}$$

λ is the wave-length sought.
$\lambda_0, \lambda_1, \lambda_2$, are three known wave-lengths.
d is the distance of the unknown from a fixed reference point.
d_0, d_1, d_2 are the respective distances of the known wave-lengths from the same reference point.

Difference Table

$d_2 - d_0$	Δd	d	λ	$\Delta\lambda$	$\frac{\Delta\lambda}{\Delta d}$
		d_0	λ_0		
	$d_1 - d_0$			$\lambda_1 - \lambda_0$	$\frac{\lambda_1 - \lambda_0}{d_2 - d_0}$
$d_2 - d_0$		d_1	λ_1		
	$d_2 - d_1$			$\lambda_2 - \lambda_1$	$\frac{\lambda_2 - \lambda_1}{d_2 - d_1}$
		d_2	λ_2		

The first two terms of the formula are a simple two point interpolation formula. Only this much of the formula need be used if approximate values are wanted. The value of the third term should be small if the results are to be reliable. A sample problem is solved with two sets of data to demonstrate the effect of separated knowns. The formula is an expression for a convergent series. If the third term has appreciable value one may not be sure that the fourth term can be neglected. The tabular

computations are made only once if three given wave-lengths are to be used as knowns for a number of interpolations. It is not necessary that the known lines be on the same photograph as the unknown as long as a fixed point for reference appears in both photographs. The tabular form can be extended to include a large number of known wave-lengths which cover a large range of values. From it one can select the three nearest for use in a particular computation.

Problem

Compute the wave-length of the line which is 4.406 mm. from the reference point. The three known wave-lengths are expressed in angstrom units in the table below.

d_2-d_0	Δd	d	λ	$\Delta\lambda$	$\Delta\lambda/\Delta d$	
		0.665	2246.98			d=4.406
	4.317			29.26	6.78	
6.877		4.982	2276.24			$d-d_1=-0.576$
	2.560			17.61	6.88	
		7.542	2293.85			$d-d_0=3.741$

$\lambda=2276.24-0.576\ (6.78)-0.576\ (3.741)\ (0.10)/6.877=2272.30$

The same problem with greater spread of known wave-lengths.

d_2-d_0	Δd	d	λ	$\Delta\lambda$	$\Delta\lambda/\Delta d$	
		0.000	2242.60			d=4.406
	7.542			51.25	6.89	
20.796		7.542	2293.85			$d-d_1=-3.136$
	13.254			98.79	7.38	
		20.796	2392.64			$d-d_0=4.406$

$\lambda=2293.85-3.136\ (6.89)-3.136\ (4.406)\ (0.49)/20.796=2271.92$

It must be remembered that the interpolated value will generally be less accurate than the values from which it is obtained. The value of λ_1 is the most important in the formula and it is safer to select a well checked value for it at slightly greater distance from the unknown line than to use an inferior value which is close.

Idaho's Batholith and Montana's Mountains[1]

By C. H. Clapp
University of Montana

Several geologists have concluded that mountain systems have wedge-shaped bottoms and have been squeezed up as the result of horizontal pressures. A study of the longitudinal faults of western Montana, both steeply dipping thrust faults and gently dipping overthrust faults, indicates that Montana's mountains have wedge-shaped bottoms. In northwestern Montana the faults have a northwest trend, in southwestern Montana a north-south trend, and in southeastern Idaho a northeast trend.

Upraised mountain blocks and volcanoes in the rift valleys of East Central Africa, around the rim of the Victoria plateau, are evidences of pressures exerted in radial directions outward from the center of the plateau. Willis[2] answering the question asked by the question mark engraved in the face of Africa suggests that the outward thrusting may have been caused by the expansion of the bottom and not the top, of the Victoria plateau, by the elongation horizontally, of the crystals of the ancient rocks of the plateau. There is also a question mark engraved in the face of the Inland Empire, but it is only half as large as the African one and it is unside down; furthermore, its center, instead of being a plateau of old crystalline rocks, as in Africa, is Idaho's batholith. It looks as if Idaho's batholith has in some way or other affected or produced pressures that have radiated outward and have aided in the squeezing up of Montana's mountains.

Batholiths, if they have behaved according to tradition, should have worked upward toward the earth's surface through thick deposits of sedimentary rocks laid down in goesynclines. But in the Inland Empire the geosynclinal deposits occur to the east and west of the Idaho batholith. As a result of the accumulation of the thick geosynclinal deposits, the earth's crust on either side of the central area now occupied by the batholith must have been depressed, causing a deep-seated crustal flow toward the central area, with a compensating uplift there. Perhaps as a consequence of the vertical pressures resulting from great uplift, the crystals of the batholith were rotated and elongated horizontally, causing horizontal radial pressures.

However, the batholith was intruded during mountain building, after the profound thrust faulting but before and during the shallow overthrust faulting. Furthermore either its marginal zone is gneissic to schistose, the foliation dipping outward from the batholith, or its contact with the intruded rocks is smooth and marked by underthrust faults with the wall of intruded rocks upthrown. These occurrences tempt me to conclude,—that as a result of the crustal flow toward the central area, the walls of the batholith were closed in, and its magma, then deep within the earth's crust, was squeezed upward. As the magma approached the surface, the region of lower pressures, it appears to have swelled outwards, like a huge mushroom, making room for itself by pushing its upper walls apart, underthrusting and overthrusting the upper part of the deformed sedimentary rocks of the surrounding geosynclinal accumulations, to uplift the mountain blocks with wedge-shaped bottoms.

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[1]Abstract of paper presented at the annual meeting of the Northwest Scientific Association, Dec. 28-29, 1932, Spokane, Washington. Published with permission of the Director of the Montana Bureau of Mines and Geology.

[2]Willis, Bailey, "Living Africa", Whittlesey House, New York, 1931.

Paleozoic Stratigraphy In Northwestern Montana[1]

By C. F. Deiss

State University of Montana

The Paleozoic rocks in northwestern Montana total about 4,800 feet in thickness, and belong to three systems; Cambrian, Devonian and Mississippian. Of these rocks the upper 4,400 feet are limestones, dolomites, and calcareous shales, and the lower 400 feet are micaceous, sandy shales, arenaceous quartzites, and thin sandstones. Approximately 90 per cent of the Paleozoic sediments consist of limestones and dolomites.

The Cambrian rocks average 1,480 feet in thickness in the central part of the basin, but thicken eastward to 2,-800 feet, and westward to 2,100 feet. These rocks are subdivided into 11 formations, only two of which can be correlated with previously described formations in other part of Montana. These are the lower two formations, the Flathead quartzite and the overlying Wolsey shale. The Cambrian rocks are Middle and probably Upper Cambrian in age. However, no erosion surface has been located between the Upper Cambrian strata and those knows definitely to be Middle Cambrian. The Devonian sediments average 940 feet in thickness, are chiefly limestones, and are subdivided into five lithologic units designated members of the Jefferson limestones. However, the Jefferson in northwestern Montant is considered to be only Middle Devonian in age, a conclusion held because neither are there Lower Devonian species in the faunas of these limestones, nor is the coral *Halysites catenulatus* present. Upon this coral E. M. Kindle based his decision of the Lower Devonian age of a portion of the Jefferson. The Three Forks shale probably is not present in northwestern Montana. The Misisippian sediments which average 740 feet in thickness are also principally limestones, and are subdivided into five lithologic units designated members of the Madison limestone. These limestones, in consonance with present opinion, are considered to be Kinderhook and Osage in age. The Brazer limestone of Idaho is present in the Sawtooth Range which forms the front range of the Rocky Mountains proper, but is absent in the Lewis and Clarke Range immediately to the west, and in the other ranges within the area.

Two erosional unconformities and one disconformity are present. Approximately 9,000 feet of Upper Algonkian argillites and quartzites were removed from the area before the basal Cambian quartzite was deposited. This thickness added to that known to be eroded in the region to the southeast indicates that nearly 19,000 feet of pre-Cambrian rocks were removed from western Montana prior to the invasion of that part of the State by the Middle Cambrian sea. The ersoional unconformity between the Cambrian and Devonian systems signifies a long interval of slight emergence of the area above the contiguous Paleozoic seas. At least 625 feet of the highest Cambrian formation was removed. No Ozarkian, Canadian, Ordovician or Silurian species have ever been found in northwestern Montana, and the writer believes that this part of the State was a positive area of low relief during these periods. The hiatus between the Devonian and Mississippian

[1]Abstract of paper presented at the annual meeting of the Northwest Scientific Association, Dec. 28-29, 1932, Spokane, Washington.

formations is attributed to local uplift in the central part of the area during Upper Jefferson time while deposition continued in the areas immediately to the north and south. The data available indicate that the difference in thickness of the limestones upon which the basal Madison limestones rest, and therefore the amount of the disconformity, is 425 feet.

Genetics of Resistance to Four Physiologic Forms of Bunt in Two Winter Wheat Crosses[1]

A. M. SCHLEHUBER[2]
State College of Washington

BREEDING for disease resistance is a part of the general crop improvement program carried on by a large number of plant breeding experiment stations. Naturally, the disease that causes heaviest losses in a particular locality should be given major emphasis at the experiment station of that vicinity.

In the Pacific Northwest, bunt is undoubtedly the most destructive disease of wheat. Gaines[3] in 1928 reported that in the Pacific Northwest as much as 50 per cent of the cars coming to the terminal shipping points were given a smut dockage. Consequently, it is only natural that a large part of the crop improvement program at the Washington Agricultural Experiment Station at Pullman deals with the breeding and selection of varieties resistant to this destructive disease.

In order to proceed most intelligently on a program of this nature, it is helpful to have considerable knowledge concerning the reaction of the parent and the breeding behavior of the progeny. The object of this paper is to present data on the reaction of three winter wheats and the F_3 progeny of two crosses to four physiologic forms of bunt.

The presence of physiologic forms of bunt has been demonstrated at the Washington, Oregon, and Minnesota experiment stations, as well as at the Brooklyn Botanic Garden in New York, the University of Alberta in Canada, and the University of Halle-Salle in Germany.

Resistance to bunt has been interpreted as resulting from one, two, and multiple factors in different crosses.

Materials and Methods

The F_2 populations of the two crosses, Albit x Minhardi and Albit x Buffum 17, were collected in the summer of 1931. The seed of each F_2 plant was divided into four portions of 75 seeds each. The first portion was inoculated with Pt-1, a form of *Tilletia tritici* (Bjerk.) Wint.; the second with Pl-5, a form of *T. levis* Kuhn.; the third with Pt-13 (*T. tritici*); and the fourth with Pt-2 (*T. tritici*). The seed was all planted by hand, spaced from three to four inches apart in

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[1]Presented at the annual meeting of the Northwest Scientific Association, December 28-29, 1932, Spokane, Washington. Published as Scientific Paper No. 250, College of Agriculture and Agricultural Experiment Station, State College of Washington, in cooperation with the Office of Cereal Crops and Diseases, U. S. Department of Agriculture.

[2]Research fellow in Agronomy, State College of Washington. The writer is indebted to Dr. E. F. Gaines for helpful suggestions and criticisms in this study.

[3]Gaines, E. F. New Physiologic Forms of *Tilletia levis* and *T. tritici*. Phytopathology 18:579-588. 1928.

rows one rod long and 18 inches apart. A pair of check rows, one of each parent, was planted after every tenth hybrid row.

Results

The percentage of bunt of the four physiologic forms on parents and F_3 progeny is shown in Table 1. Albit is immune to Pt-1 and Pl-5, but highly susceptible to forms Pt-13 and Pt-2. Minhardi is susceptible to all four forms; Buffum 17 possesses a slight resistance to form Pt-1, but is susceptible to the other three. The average per cent loss from bunt on the F_3 families is comparatively low with Pt-1 and Pl-5 but high with Pt-13 and Pt-2.

The distribution into bunt classes of parents and F_3 for four forms is shown in Table 2, and for forms Pt-1 and Pl-5 is shown graphically in Figure 1. The minima in the curves indicate the divisions of the different

Table 1. Reaction of Parents and F_3 Progeny to Four Physiologic Forms of Bunt.

Parent or progeny	Per cent loss when inoculated with Pt-1	Pl-5	Pt-13	Pt-2
Albit	0.0 (8)*	0.0 (10)	76.3 (6)	80.0 (11)
Minhardi	63.6 (15)	80.2 (14)	86.9 (13)	89.8 (12)
Buffum 17	34.4 (10)	60.2 (11)	70.5 (9)	68.8 (9)
Albit x Minhardi F_3	12.4 (57)	23.6 (104)	82.6 (80)	81.8 (89)
Albit x Buffum 17 F_3	24.5 (62)	33.1 (84)	80.1 (28)	83.4 (56)

*Numbers in parentheses indicate the number of rows or progenies used in calculating the average. Only rows with 15 or more plants were used, this number being chosen quite arbitrarily.

Table 2. Distribution of Parents and F_3 Progenies according to Their Relative Susceptibility to Four Physiologic Forms of Bunt. Size of Classes Increases from 0 by an Arithmetical Progression of One Per Cent.

Parents and F_3 progenies	Bunt form	Number of Rows in each class: 0	t-1	2-3	4-6	7-10	11-15	16-21	22-28	29-36	37-45	46-55	56-66	67-78	79-91	92-100	Total No. of rows
Albit	Pt-1	15															15
Buffum	Pt-1							2	2		4	2					10
Minhardi	Pt-1									1	1	2	3	7	1		15
A x B F_3	Pt-1	8	1		4	7	7	6	8	3	6	5	5	1	1		62
A x M F_3	Pt-1	26	1		3	6	4	6	2	2	2	1	2		2		57
Albit	Pl-5	19															19
Bucum	Pl-5									1		2	3	5			11
Minhardi	Pl-5													4	10		14
A x B F_3	Pl-5	11		1	11	6	10	10	6	2	2	8	6	10	1		84
A x M F_3	Pl-5	35		2	6	5	11	13	9	3	3	5	8	3	1		104
Albit	Pt-13											1	1	4			6
Buffum	Pt-13										1	3	3	1	1		9
Minhardi	Pt-13												1	10	2		13
A x B F_3	Pt-13										3	2	5	12	6		28
A x M F_3	Pt-13										1	4	17	40	18		80
Albit	Pt-2											1	4	6			11
Buffum	Pt-2									1		2	6				9
Minhardi	Pt-2													9	3		12
A x B F_3	Pt-2										1	2	10	29	14		56
A x M F_3	Pt-2											3	28	46	12		89

F_3 families into their respective phenotypes. Recently Briggs[4] demonstrated that the minima in the curve indicates the division between phenotypes quite accurately. Such a division was made in Figure 1 of the F_3 families of Albit x Minhardi, inoculated with Pt-1, with the exception that the homozygous resistants were placed on 0 per cent smut, as in the resistant parent, rather than on two per cent as the minimum. The other two minima fall on 12.5 and 50 per cent. When these divisions are made, the number of families in each group is as follows:

26 homozygous resistant
12 heterozygous resistant
15 heterozygous susceptible
4 homozygous susceptible

The numerical distribution of these four groups suggests a 7:4:4:1 ratio that can be explained satisfactorily on a two main factor difference. The expected numbers for this ratio are 24.93:14.25:14.25:3.57. Fischer's[5] P, A Test for Goodness of Fit, for the observed and calculated numbers for a 7:4:4:1 ratio yields the highly signifi-

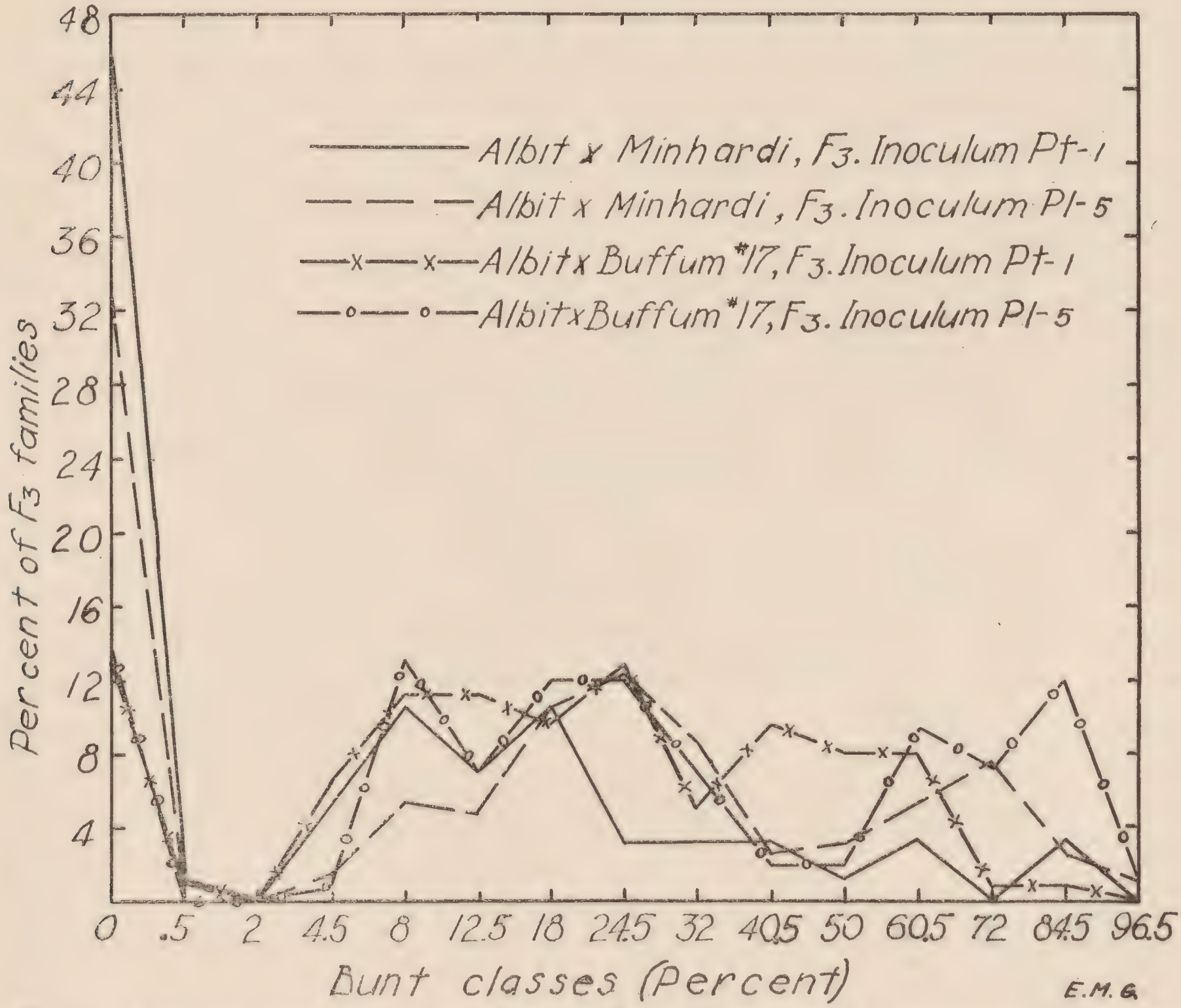

Fig. 1. Inheritance of resistance to two physiologic forms of bunt in two F_3 populations. The reaction of Albit x Minhardi indicates two main dominant factors for resistance to both bunt forms. Taking the low point in the curves as the dividing lines between groups, the ratio is 7:4:4:1. Buffum 17 introduces an inhibitor of the resistant factors which reduces the proportion of smut-free families and increases the proportion of highly susceptible classes. Pl-5 is somewhat more virulent than Pt-1 in these particular crosses.

[4]Briggs, F. N. Inheritance of Resistance to Bunt, *Tilletia tritici,* in Hybrids of White Federation and Odessa Wheat. Jour. Agr. Research 45:501-505. 1932.

[5]Fisher, R. A. Statistical Methods for Research Workers. 282 pp. Oliver and Boyd, Edinburgh. 1930.

cant value .93, i.e. only seven times out of 100 would as good or better fit resulting from chance alone be expected. The curves representing the bunt on the F_3 progeny of Albit x Minhardi inoculated with Pt-1 and Pl-5 show some similarity. The relationship between the two bunt forms is shown in Table 3. The correlation coefficient r is .956±.008. There are three well defined groups in the correlation surface. If all the frequencies except those in the two homozygous classes are considered as the heterozygous group, the observed as well as the calculated ratio is 21:24:3, indicating an excellent fit. Evidently, the same two main factors that are responsible for resistance to Pt-1 also control the resistance to Pl-5.

Table 1 shows that Pl-5 is a more virulent form than Pt-1 for both the parents and the offspring. When the minima in Figure 1 of the Albit x Minhardi F_3 progeny inoculated with Pl-5 are taken as the points of division between phenotypes, it must be assumed that an inhibiting factor for A^1 which is activated by Pl-5 but dormant in the presence of Pt-1 is carried by Minhardi. On the basis of this three factor assumption, the theoretical numbers for the 19:8:30:7 ratio compared with the actual in each group is:

Theoretical	Actual	Group
30.9	35	homozygous resistant
13.0	10	heterozygous resistant
48.7	47	heterozygous susceptible
11.4	12	homozygous susceptible

In this comparison, P is .72, indicating the hypothesis is probably correct.

Albit, Minhardi, and Buffum 17 do not possess genes for resistance to Pt-13 and Pt-2 or, if any, they are only minor factors.

The graphic distribution into bunt classes of the parents and the progeny

Table 3. Correlation between Smut Forms Pt-1 and Pl-5 in 48 Progenies of Albit x Minhardi F_3

		P1-5															
		A^2A^2	A^2a^2												a^2a^2		
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
A^1A^1	1	21							1								22
	2	1															1
	2																0
	4	2			1	1			1								5
	5					1		1		1	1						4
A^1a^1	6						2				1						3
Pt-1	7						1	2	1			1					5
	8							1									1
	9									1			1				2
	10										1						1
	11											1					1
	12														1		1
a^1a^1	13																0
	14												1			1	2
	15																0
		24	0	0	1	2	3	4	3	2	2	1	2	2	1	1	48

r=.956±.008 P=1 for 7:8:1 ratio

Table 4. Correlation between Smut Forms Pt-1 and Pl-5 in 53 Progenies of Albit x Buffum 17 F_3

		Pl-5															
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Pt-1	1	5			1												6
	2																0
	3																0
	4	1				1		1									3
	5					1	2	1	1	1							6
	6					2		2	1								5
	7	1					2	1	1								5
	8						1	4	3		1						9
	9					1								1			2
	10					1							2	2	1		6
	11										1		1	1	1	1	5
	12										1		1	1	1		4
	13													1			1
	14														1		1
	15																0
		7	0	0	1	6	5	9	6	1	3	0	4	6	4	1	53

r=.855±.003

of Albit x Buffum 17 to Pt-1 and Pl-5 is presented in Figure 1. The low number of families—62 for Pt-1 and 86 for Pl-5—prevents a satisfactory analysis of the progeny. It appears, however, that multiple factors, probably four, are responsible for resistance in this cross. There is a striking similarity in the curves representing the two different inoculations. This similarity or relationship is shown in the correlation surface, Table 4, in which r is .855±.003, indicating that Pt-1 and Pl-5 possess a relationship in the Albit x Buffum 17 cross similar to that found in the Albit x Minhardi cross.

The average per cent bunt of Buffum 17 (Table 1) was 34.4 (10 rows) when inoculated with Pt-1 and 60.2 (11 rows) when inoculated with Pl-5, as compared to 63.6 (15 rows) and 80.2 (14 rows), respectively, for Minhardi. Yet the average per cent bunt of the Albit x Minhardi F_3 progeny is considerably lower than for the F_3 progeny of Albit x Buffum 17. The nature of the distribution into bunt classes of the two crosses, as brought out in Table 2, indicates that Buffum 17 possesses a gene complex for resistance that is quite different from that of Minhardi.

Conclusions

Data are presented on the reaction of three winter wheats and the F_3 progeny of two crosses to four physiologic forms of bunt.

The F_3 progeny of both crosses are completely susceptible when inoculated with forms Pt-13 and Pt-2 to which both parents are susceptible, but a series ranging from complete immunity to complete susceptibility is found in the F_3 when inoculated with forms Pt-1 and Pl-5 to which one parent is immune and the other susceptible.

In the F_3 generation of the Albit x Minhardi cross the four classes, homo-

zygous resistant, heterozygous resistant, heterozygous susceptible, and homozygous susceptible, gave a close approximation to a 7:4:4:1 ratio to form Pt-1. The results indicate a two main factor difference.

The high value of *r*, .956±.008, between Pt-1 and Pl-5 indicates that the same two *main* factors responsible for resistance to form Pt-1 are also responsible for resistance to Pl-5. Minhardi introduces a factor which prohibits the action of A^1.

Neither Albit, Minhardi, nor Buffum 17 possesses genes for resistance to forms Pt-13 and Pt-2.

It is suggested that resistance in the F_3 of Albit x Buffum 17 to Pt-1 and Pl-5 is due to multiple factors not to exceed four.

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THE SECRETARY, BROOKLYN BOTANIC GARDEN

1000 Washington Ave., Brooklyn, N. Y., U. S. A.

NORTHWEST SCIENCE

SEPTEMBER

1933

Vol. VII Number 3

73
7

Published by

The

Northwest Scientific Association

Single Copy Thirty-five Cents

NORTHWEST SCIENCE

A scientific journal published quarterly by the Northwest Scientific Association and devoted to the dissemination and promulgation of scientific effort in the Pacific Northwest

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NORTHWEST SCIENCE

Entered as second class matter April 5, 1927, at the Post-Office at Cheney, Washington. Office of Publication, Cheney, Wash.

Published quarterly at a subscription price of $1.00 per year, which includes the membership dues of the Association. Non members $1.00 per year. Vols. I (1927), II (1928), III (1929), IV (1930), V (1931), complete, each $1.25.

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Printing of plates extra, at actual cost

NORTHWEST SCIENCE

VOL. VII SEPTEMBER, 1933 No. 3

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EDITORIAL

MANY phenomena with which we are familiar appear to operate in cycles. We are told that there occur, somewhat irregularly to be sure, cycles of weather, insect epidemics, human diseases, and economic depressions. Perhaps the latter has focused our attention more than any other and whether or not we did it voluntarily we have, during the past year or so, absorbed a mass of information and many predictions concerning this disturbing influence in our lives.

All economic prophets to the contrary, we are still battling with depression forces and although the trend is toward recovery and the banishment of fear, yet certain groups such as teachers, and the workers in science will be left on the shoals for a time as the rising tide of recovery sweeps wages, salaries and costs of commodities to a higher level. The teaching class, among the first to feel the ax of curtailment during economic slumps, are also the last to be restored to normal salary levels when the swing of economic activity restores former price and salary levels. This is a dilemma which has faced workers of this type during all economic crises. When economic conditions are favorable salary increases for them are slow and far apart; whenever business activity drops off, salaries are rapidly reduced; and then when recovery again takes place, the slow laborious effort to regain lost ground is handicapped by meeting rapidly rising living costs with greatly reduced funds and the lower purchasing power of money. In recovery times this lag is most pronounced in occupations which are somewhat less directly concerned with business activities and is the penalty which educators and scientists must pay for being what they are. No matter if the love of the chosen work buys no bread and there are no Blue Eagles of the N. R. A. flying to their rescue there is always the consoling thought that despite the odds the members of this group are never lacking in that willingness to carry on which always characterizes those who select their occupation because they like it.

The Basket Makers and the People of the Ancient Culture of the Fremont River in Utah

By Albert B. Reagan[1]

WE hear much about "Basket Makers" these days, and detailed discussions concerning them and their civilization are given in various archaeological publications, especially in Roberts' report on the Piedra District and in other like publications.[2] That phase of the subject needs no further mention. Who were these people, what ultimately became of them, and what relation were they, if any, to the people of the ancient Fremont Culture of the Fremont River in Utah will be the gist of this paper.

The term "Basket Maker" as the name for any particular aborigines of America is a misnomer, as many different tribes were not pottery makers but basket makers when first met by white men. Such were the Northwest Coast Indians, at least part of those of the Columbia River basin, at least most of the Shoshoneans of the interior region, and various other tribes of the West, including the Apaches and Navajos, the latter being reported to have possessed a crude pottery. So the term "Basket Maker" gets us nowhere. It might also be added that soon after Drs. Kidder and Guernsey's two papers came out on the archaeology of Northeastern Arizona,[3] a white man of past middle life, who had been partly raised by the Paiutes, visited me on business. He had lived with the Indians of Arizona and Utah all his life and on account of having been on the frontier with them, he was unable to read and write. As we were talking, a copy of "Basket Maker Caves of Northeastern Arizona" lay before me on the table; and I casually opened it at one of the plates that showed Basket Maker artifacts. He took the book at once and glanced through it at the cuts, as he again and again exclaimed, "Paiute stuff!" Interested, I handed him the other publication "Archaeological Explorations in Northeastern Arizona," and through it he leafed, designating the cuts of Basket Maker things as "Paiute stuff" in every case. This and the things mentioned above led to the investigations which brought forth this paper.

In discussing the Basket Maker culture, Kidder and Guernsey (3a, op. cit., pp. 210-212) make these statements: "Whether the Basket Maker culture is parent to that of the cliff-dwellers and the Pueblos of the region; whether it died out entirely; or whether it still persists among such seminomadic people as the Ute and Paiute cannot be definitely stated. We know much too little about the comparative technology of the Southwest . . . . The basketry bears a strong resemblance to that of California, but the similarities are perhaps superficial rather than real. Contact with California, however, is proved by the presence in Basket Maker caves of Pacific Coast shells as the abalone . . . The correlation of these branches of inquiry (basketry, the making of sandals, beads, etc., both by prehistoric peoples and by modern Indians), taken together with somatological researches and a consideration of the geographical range of the Basket Makers, can hardly fail to throw much light on the questions of who they were and whence they derived their culture, whether or not it was parent to that of the Cliffdwellers or whether it was the forerunner of some other culture,

possibly that of the modern Ute or Paiute."

On this same subject these two men again make statements as follows (3b, op. cit., pp. 115-116): "As to the origin of the Basket Makers, it may be said that several traits, such as corn growing and the use of the atlatl, point toward Mexico. The peculiar curved, grooved hand-club, and the method of hairdressing were both features of the somewhat Mexicanized Maya culture of late prehistoric and early historic times in Yucatan . . . . We have examined collections from many modern southwestern tribes who possess cultures of about the same grade as that of the Basket Makers, in the hope that we might find some evidence of their descent from the ancient people. Nothing definite could, however, be established, although similarities in basketry, rabbit-nets, and hair ornaments were noticed in Paiute collections; and, among the Mohave material, in the form and weave of twined bags and in the practice of plugging with wood the quills of feathers. Too much significance, however, must not be placed upon similarities such as the above, for the remarkable state of preservation of the Basket Maker material makes it appear so much like a collection from an existing tribe that it is particularly easy to fall into the way of drawing technological comparisons between it and modern articles, losing sight of the fact that the Basket Maker products are really of great antiquity and that the Paiute, Mohave, and other collections are things of yesterday."

Dr. Kroeber, in writing about the basketry of the upper San Joaquin Valley in California, also makes remarks about the Basket Makers of Grand Gulch, as follows:[4] "The same (as had been said about a wooden 'potato-masher'-shaped war club) may be said of a number of bags twined in basketry technic but of soft string material . . . . These are similar to the bags and wallets made by the Diegueno and Mohave,, and bear an especial likeness, at any rate superficially, to utensils of the so-called 'basket makers' who once lived at Grand Gulch, in southern Utah."

In one of Dr. Roberts' reports he says:[5] "Some of the investigators profess to see in the modern Mohave and Paiute peoples the remains of the old Basket Makers. Others are of the opinion that they were completely absorbed by the new arrivals (the Pueblos) in the Southwest and that all traces of them were obliterated through the resulting mixture and the widespread practice of cranial deformation. The problem is yet untouched." And Dr. Guernsey says:[6] "Basket Maker II and Basket Maker III people appear to have been much more heavily boned than were those of the later (Pueblo) cultures, closely resembling, physically, the Paiutes, whose ancestors they may well have been."

Other references could be quoted but the above citations are enough to show that the preponderance of opinion is toward believing that the so-called Basket Makers were ancestors of the Paiutes (and Utes) of our day, whom the writer will here call Utiouan people. This belief is further strengthened by the results of investigations which show that the Basket Makers lived much the same as did the Paiutes in the same and adjoining areas when first visited by white men. Geographical location of the Ute-Chemehuevi peoples surrounding the Pueblo country on practically all sides except on the south—the great, much-bent bow to the Pueblo taunt bowstring—also shows that these people have been in contact with each other, possibly for ages. Furthermore, it does not seem at all impossible that the Utiouans ex-

tended their territory even into old Mexico before Pueblo times, even to the territory of their kin-folk, the Aztecs; and such connection may have also been made at several different times since then. Or, on the other hand, it is quite possible that the in-driving of the Pueblo wedge separated the two major divisions of the Uto-Aztekan family, driving the Shoshonean family northward where it was found by the in-coming whites. Be that as it may and as future investigations will determine, the boundary line between the Utiouans (and their descendents, the Ute-Chemehuevi, in historic times) and the Pueblos has been a wavy line that has swayed back and forth with the raids of one or the other peoples, the Utes being mostly the attackers of the Pueblos since the coming of Colorado. In other words, the Utioux (pronounced, U-'too) and Pueblo peoples have contended with each other for a long period of time; and the border line between the lands respectively occupied by them has been a line of raids and counter raids and also a line (often a wide strip of country) where the two peoples mixed. Moreover, the dominant aggressor would capture the most women and would, of course, show the greater mixture in head deformation, or non-head deformation, and so on, as Pueblo or Utioux gained the ascendency. And such the investigations show.

Now about the ancient culture of the Fremont River: In Pueblo No. II times a people of a peripheral culture occupied the Fremont River region in southern Utah, extending their domain northward along Green River and its tributaries probably into Wyoming. In general features, their culture remained at the Basket Maker III level, as shown by the pottery, the figurines, the absence of cotton and turkeys, the twined-woven mats, the fur cloth, the relative abundance of coiled basketry and the absence of plaited basketry, the various snares, and the general shape of the anthropomorphic pictographs. On the other hand, the bow and arrow, mountain sheep pictographs, stone drills, and possibly occasional head deformation show culture traits in common with the early Pueblo culture with which it had contact.[7] Again, in the Vernal district of northeastern Utah this same culture shows traits in its pictographs which seem to ally its people strongly with the Ute-Chemehuevi Indians, in the drawings of bear dance scenes, women carrying cradles, and in many other characteristic pictographic scenes. Here also are scenes depicting the Fremont peoples as returning from raids with captured women and children and the heads of the braves who dared defend their homes, some of the captured women being depicted as wearing butterfly-winged whorled hair as Hopi virgins wear their hair at the present time.[8] In view of the fact that the culture of this people was mainly of the Basket Maker III level, the remaining part of that culture being obtained by contact with neighboring Pueblos and through the captured Pueblo women, the writer here terms the "ancient culture of the Fremont River in Utah" Basket Maker IV, as it was later in time than Basket Maker III, coinciding in the time scale, in the main, with Pueblo No. II times.

Furthermore, in view of the fact that the whole Basket Maker culture as it has been considered, including Basket Maker IV of this paper, is the culture of the Utioux (ancient Ute-Chemehuevi) branch of the Shoshonean family of Indians, as previously pointed out, the writer suggests that the indefinite term "Basket Maker" be changed to Utioux, the

stages of that culture to be designated as Utioux I, Utioux II, Utioux III, and Utioux IV.

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Forest Utilization Research Needs for the Future In the Inland Empire[1]

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THE needs for forest utilization research are basically the same in all the forest regions of the United States. They are affected, of course, by special factors which vary in different localities. Most of these factors are directly economic or they are indirectly so because of present demand and price conditions.

In this region the long rail haul is a direct economic factor. The inaccessibility and the consequent difficulty of logging extensive areas, the threatened loss of large stands of species of very low market value are other factors to be contended with in this region.

The National Committe on Wood Utilization has recently published a report by H. K. Benson[3] on the "Chemical Utilization of Wood." Benson has this to say in regard to Idaho; "In the utilization of the forest for lumber production there is further economic loss"—besides the loss in the form of logging and sawmill waste of 60 per cent of the timber cut—"due to the so-called inferior species. In the state of Idaho, for example, is found an excellent stand of western white pine (Idaho white pine) which will continue to feature largely in its lumber production. In this same region occur also extensive stands of western yellow pine (Ponderosa pine), western larch, Douglas fir, lodgepole pine, white and Alpine fir, Engelmann spruce, western red cedar, west coast hemlock, and white bark pine. Due to rough topography and inaccessibility, logging costs are sometimes prohibitive. In other cases, the lumber demand for certain species listed is insignificant. It is believed by some that more than three-fourths of the standing timber of Idaho must ultimately be used for purposes other than lumber. In its utilization, chemistry and technology will no doubt play an important part".

As Benson points out western white pine is the most valuable tree in this region. With this species, however, we are facing a very severe protection problem, particularly against blister rust and bark beetles. The Annual Investigative Report for 1932 for the

[1]Presented at the annual meeting of the Northwest Scientific Association, Dec. 28-29, 1932, Spokane, Wash.

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Northern Rocky Mountain Region of the Forest Service[11] points out that the best answer to the white pine problem "is probably a compromise somewhere between the abandonment of western white pine as a major commercial species and its complete protection from all enemies throughout its range". This situation has a direct bearing on utilization research in the Inland Empire. Should the stands of white pine decrease it will mean that we must turn to the active utilization of other species or suffer the loss of a large part of our forest industry and investment in this region. The time for intensive utilization research on species other than white pine is *now,* rather than to wait and determine whether or not white pine can be adequately protected.

The need for intensive research on the utilization of the so-called inferior species is pertinent even if the threat to white pine did not exist. Western white pine makes up about 20 per cent of the total timber stand in Idaho and only about 12 per cent of the combined Montana-Idaho stand. We have enormous stands of species available in this region which are not considered high-quality lumber species. We have ample reason for aggressive research to determine the qualities of the wood of these "poor seller" species for their best use either as lumber and unmodified wood or as raw material for wood conversion industries.

Forest utilization research in the Inland Empire must be influenced by the above factors, namely, the great percentage of species of low market value, the difficult accessibility of large timber areas and the high cost of harvesting, the threat to white pine, and the costly transportation of timber to the eastern markets. Besides these local regional influences there are factors of national scope such as the depressed and shrinking lumber market, the severe competition of other materials, the capital outlays for production facilities by forest industries in excess of the need, the taxation problem and others.

These problems make forest utilization research a necessity, particularly so in this region because of the additional local factors mentioned. Diversified products and integrated fabrication from wood as a raw material would appear to be the best means for forest enterprises to return to a sound profit basis. It is the best hope for a net stumpage return which will justify and enable industries to practice good forest management.

In considering utilization needs the discussion may be conveniently divided into three topics, (1) lumber and its competition with other materials, (2) sawmill and woods waste, and (3) the so-called inferior species. Of course it is recognized that there is considerable over-lapping among these arbitrary divisions.

The utilization of wood in chemical and technological processes will be given special consideration under a fourth heading.

Lumber and Its Competition With Other Materials: Lumber is our pre-eminent forest product. Yet the amount of research spent on lumber is trifling in relation to the efforts put into the development for special uses of such materials as iron and steel and concrete.

In considering lumber research needs, the fact that the Inland Empire is principally a lumber exporting region must be kept in mind. Lumber research must therefore be directed toward the improvement of lumber for the national and even the foreign market.

The program[7] for a forestry exhibit in Berlin last winter had this to say: " . . . within the last decade German industry has been turning to steel, iron

and cement as a substitute for wood in manufacture, construction and building. While this subtle change has been going on practically nothing has been done by foresters or others concerned to counteract it."

These words are equally appropriate for this country.

What are the best lines of attack? Cartwright[6] gives two, "(1) properties of wood can be influenced by physical or chemical measures or more closely controlled by selection to offer the user a greater variety of choice or a more uniform product for his purposes, (2) the user can be shown how to adjust the material more economically or more effectively to his purpose."

In order to carry out these measures much more wood technology research is necessary on the physical properties of wood directly related to specific uses (as for example, the holding power of screws), and also on the technic of turning out improved and more economical designs. Such information is lacking on most Inland Empire species, particularly the "poorer quality" species. An exception is western larch. Johnson and Bradner[10] of the Forest Service have published a bulletin on western larch including a comprehensive study of the mechanical and physical properties of the wood in relation to its uses. Such information on the properties of all Inland Empire species should be available to every potential user.

Full information on the properties and best uses of lumber is only partly available. Knowledge of the insulating value of wood has only recently been secured in systematic form. It is by the accumulation of such data that wood can begin an offensive against other materials. Such a beginning is being made. For example, because of its insulating value wood is replacing metal as an interior finish for Canadian Pacific air conditioned Pullman cars.[12] Some German radio towers have been built of wood because of its non-conducting property. Automobile bodies made entirely of plywood[7] have been exhibited in Berlin.

Much research is necessary to modify and control the properties of wood and to introduce new properties. Wood is now commercially produced which is fire-resistant, but the cost prohibits its use except in the fire zones of cities having fire building code laws. In the laboratory wood may also be rendered moisture proof and hence warp and shrink proof. Wood which would have these fire and moisture resistant properties, and which could be produced reasonably cheap would be in great demand. Research on a one-operation seasoning and moisture and fire resistance process may ultimately bear practical returns.

In the laboratory, Inland Empire species may have their hardness and density increased beyond that of the heaviest hardwoods, and at the same time be made fire and moisture resistant. If the process could be put upon a practical basis, the product would have many uses.

Utilization of Sawmill and Woods Waste: Research on the utilization of sawmill and logging wastes is an urgent need in this region and one which would probably result in the most immediate practical returns. Sawmill waste is available in large amounts at central points. Logging waste, including culls and broken logs, together with small sizes and inferior species could be brought out at the same time as sawlogs.

A recent study by Anderson[2] of the utilization of the timber species cut in northern Idaho and western Montana gives us an accurate estimate of the wood lost in converting western white pine, western yellow pine, western larch, and Rocky Mountain Douglas fir to lumber and timbers. The aggre-

gate loss in logging and milling amounts to 55 million cubic feet annually. If the lumber companies could convert this material into a series of products and properly market them it would enable a greater financial return from the land and the capital investment.

Boyce[5] points out in a recent paper that "To permit the highest degree of integration and diversification new uses may play an important part in the program of an individual going company, particularly if material wasted in other or higher forms of manufacture can be utilized. Here is presented the best means of converting into a salable product the highest percentage of material grown. The extent to which this integration is accomplished is not only a measure of commercial success but also of the general development of new uses and waste utilization".

In the Inland Empire approximately 30 per cent of the sawlog goes into waste and such by-products as lath, moulding, short box, and fuel; about 60 per cent of the material being used as mill fuel. Of course material used by the power plant is not wasted, yet it does not supply a direct source of income. Hogged chips and sawdust are used as fuel because other uses have not been devised which would put a value on them beyond or equivalent to the cost of using other fuel. Lath and other manufactured articles utilize only a relatively small portion (6-18 per cent) of the total sawlog waste. Furthermore the manufacture of such articles requires careful selection of the waste and as much as 85 per cent of the selected material is returned to the waste conveyor. The efficient utilization of sawmill waste in the Inland Empire is therefore far from complete and the utilization of logging waste is yet to begin.

Research on sawmill waste in the Inland Empire should be first directed toward building up a small but stable market, preferably local at first, for a number of diversified products produced either chemically or otherwise. We have a good example in the fuel briquette for domestic heating and cooking developed[4] at Potlatch Forests in Lewiston, Idaho. The excellent qualities and advantages of this fuel should insure an ultimate large market for this product. In Europe the wood briquette has a definite place in competition with other fuels.

The present chemical utilization of wood waste other than for pulp in the United States uses but a relatively small volume of wood and the market for the products is not large. However, as pointed out by Hawley,[8] "there is so much wood waste available that even a low value given to even a small part by chemical utilization would amply repay great efforts to develop the successful waste utilization process".

Waste utilization research needs in this region are, first, the development of a few diversified products to supply a small stable market, and second, the development of products demanding large volume consumption of wood and having wider markets, and which require either the correlation of the sawmill with other industries or the capital development of by-product plants by the sawmills themselves.

Utilization of the So-Called Inferior Species: Research on the greater utilization of Inland Empire species other than western white pine is perhaps in the ultimate and broadest sense the most important utilization research need. As Benson[3] points out, three-fourths of the Idaho timber stand may ultimately have to be utilized for purposes other than lumber.

Discussion of the utilization of these species may be divided into three groups.

(1) *Lumber and products without physical or chemical alteration of the wood.* As pointed out under the discussion on lumber more complete information on the properties and uses of the wood of these species is necessary in order that the user may appreciate their fullest value for various uses.

(2) *Pulp and molded products.* White and alpine fir, Engelmann spruce, and black cottonwood are all excellent pulpwoods. The market for these species should be extended. All Inland Empire species are suitable for fiber boards and molded pulp articles. Research on improving these products such as making them fireproof and in developing cheaper pulping methods may bring this industry to this region as a corollary to the sawmill. Then both sawmill and logging waste and "inferior" species may be used for pulp.

(3) *Chemical products.* The development of chemical as well as of pulp products from sawmill waste would enable the logging of "poor" lumber species along with the sawlogs where possible. These could then be converted into by-products together with the sawmill and logging waste. On the West coast some companies which sell sawmill waste for pulp chips have found it economically possible to bring out smaller hemlock and spruce logs than formerly.[9]

Some products may be obtained only from definite species. Galactan from western larch is an example. New patents[1] on the preparation of mucic acid from galactan were granted only last year. This is not the only product possible from this raw material however, and research is needed to develop other products.

Chemical Utilization of Wood: The chemical utilization of wood in the Inland Empire should be directed primarily to the development of products which can be produced in correlation with the lumber industry. This may result either in the direct manufacture of the products by the lumber industry, or in the sale of wood to the chemical industries, or in other cases the effecting of joint harvesting operations where possible in order to lower costs.

Most products produced by chemical means require considerable plant equipment. It might be well in this region to first direct research toward the development of products not requiring too heavy an expenditure of capital. For example, some materials might simply be extracted (as galactan) and sold as an unfinished product. Other products may be made by relatively simple means such as artificial stone or tile from shavings mixed with various cements or chemicals and dense articles for gears, washers, and insulators. Wood treated in a simple manner with certain aldehydes or other chemicals gives a product analogous to Bakelite and has properties which suggest a possible wide chemical use.

It is also desirable that utilization research be carried on now for the development of commodities having wide market demand, an appreciable consumption of wood, and preferably the consumption of wood without regard to species or physical shape. The development of plastics, cattle food, industrial chemicals, motor fuel, and the direct conversion of wood to "cellulose products" are a few possibilities among many others.

Recent research has added significance to the theory that wood may be converted directly without the removal of lignin into lacquers, films, rayon, and other products.

The possibilities of the catalytic and pressure conversion of wood into motor fuel and industrial chemicals are still in the experimental stage.

Laboratory research indicates that lignin may yield dyes, explosives, binders, plastics, tanning material, flavoring extracts, and other products. Long research is necessary to reveal the nature of lignin and such theoretical investigations should be pressed. In this region practical problems call for immediate attention. Even in the case of lignin we have sufficient information at hand to attempt its utilization along certain limited lines.

Conclusions

The above possibilities for the chemical utilization of wood are just a few which recent research has disclosed. The use of wood in chemical processes for industrial purposes is of growing importance. Therefore in forest utilization chemical research should be given considerable thought.

In conclusion I believe that utilization research in the Inland Empire should be directed toward the ultimate goal of integrated forest industries. This situation will insure the most efficient utilization of the raw material of the forest and place forest industry on a diversified products basis. The first steps in such a program are (1) a thorough study of the main product at hand—lumber in order to understand its present possibilities, (2) research on the modification of the properties of wood, thereby extending its range of uses and (3) intensive research on the development of a few diversified products from waste and the inferior species which will be insured of a stable market demand even though local or small at first.

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Stagnation of the Okanogan Lobe of the Cordilleran Ice Sheet and the Resulting Physiographic Effects[1]

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IN recent years Richard F. Flint[2] has described glacial features which have led him to conclude that in New England the last ice sheet stagnated and slowly dissipated itself in situ and that it did not retreat as has been previously believed. Even in the Great Lakes area, a classic ground for recessional moraines, local areas where ice stagnation occurred have been found.

Without having visited the area, Flint states (Geog. Rev. Vol. 19, page 286) 'the topographic maps covering Okanogan County, (Washington) . . . show extensive horizontal terraces and abandoned spillways in profusion. The relations exhibited suggest that stagnation may have affected the latest ice in that region."

Field studies conducted by the writer in the summer of 1932 disclosed abundant evidence of ice stagnation toward the close of the Wisconsin epoch throughout the whole Okanogan Valley and a small area in northern Douglas County.

The Okanogan lobe of the Cordilleran ice sheet during the last glaciation covered all of Washington north of the Spokane and Columbia rivers. It even crossed the great gorge of the Columbia, 2000 feet deep, near the Big Bend, and extended south across the Waterville Plateau for 25 or 30 miles. The crossing of the Columbia River canyon by the ice proves that the Okanogan glacier, while advancing, possessed great momentum. Pardee (U. S. G. S. Bull. 677, page 52) estimates that the ice was 4,000 feet thick above the bed of the Columbia River. The moving ice wrenched loose enormous boulders of basalt from the cliffs at the edge of the Okanogan and Waterville plateaus and left them as great erratics scattered over the surface farther south together with smaller foreign boulders of crystalline rock. The ground moraine is generally many feet thick with numerous hollows that contain ponds in wet years and rainy seasons. Farmers have well named the big basaltic erratics "haystack rocks". Many of them completely dwarf the houses and barns. Some are possibly the largest erratic boulders in the United States. One is 50 feet high and broader than a large house and barn put together.

On the Waterville Plateau the Okanogan lobe deposited a prominent terminal moraine about a mile broad which is pitted with potholes and studded by "haystack rocks." The moraine descends cliffs 800 feet high and crosses Moses Coulee in a spectacular manner eight miles east of Withrow, about a mile south of Jameson Lake. The large size of the terminal moraine proves that the ice advanced across the Columbia gorge and maintained itself for a considerable time.

Toward the close of the Wisconsin epoch the ice sheet stagnated and slowly wasted away. A mass of ice covering perhaps 100 square miles east of Mansfield endured longest. Evi-

[1]Presented at the annual meeting of the Northwest Scientific Association, Dec. 28-29, 1932, Spokane, Washignton.

[2]Glacial Geology of Conn. Bulletin 47, Conn. Geol. and Nat. Hist. Survey, 1930, Stagnation and Dissipation of the Last Ice Sheet, Geog. Rev., April, 1929.

dence of stagnation is plainly seen along the main highway between Coulee City and Mansfield. The proof of stagnation consists of eskers deposited in sub-glacial streams and kames deposited in holes in the ice.

Ten miles east of Mansfield the highway cuts across three parallel eskers . The eskers are 20 to 40 feet high and several hundred rods long. They extend nearly north and south. The material is sand and rather fine gravel all well stratified. The strata dip steeply east and west from the center. Several other eskers occur in this area of stagnation. At Del Rio there is a sinuous esker-like deposit extending nearly east and west but it is so stony that it seems unlike a typical esker.

Scores of kames dot the Mansfield area of stagnation. The kames consist of conical or dome-like hills of well sorted and stratified gravel. They may occur singly, in irregular groups, and in rows. Twelve miles east of Mansfield there is a group of about ten kames ranging from 50 to 100 feet high. Eight miles east of Mansfield a hill of basalt successfully resisted glacial attack and caused crevassing of the ice. Stratified fluvioglacial deposits filled the crevasses and holes. Today these deposits appear as kames that diverge fanlike to the direction of the ice motion and so on the south of the basalt hill. One mile northeast of Withrow a conical kame lies in front of the terminal moraine. This doubtless resulted from deposition along the front of the ice from a surface glacial stream and is much like an alluvial cone. Considerable outwash gravel has been deposited on the bench at Withrow.

Practically all of the melt water from the ice sheet on the Waterville Plateau drained into Moses Coulee. At the head of Moses Coulee canyon there is a dry waterfall about 100 feet high. Obviously the canyon was extended headward by retreat of a waterfall during the glacial period. Above the canyon Moses Coulee becomes a broad, mature valley in striking contrast with the youthful gorge below. Grimes Lake and Jameson Lake, each about one to two miles long fill depressions in the floor of Moses Coulee in the upper part of the canyon. The lower end of Grimes Lake is blocked by gravel bars interspersed with potholes that are probably old plunge pools of a receding waterfall. South of Jameson Lake there are water-assorted gravel deposits which merge with the terminal moraine that crosses the coulee.

The Okanogan glacier completely filled the Columbia River canyon and towered one or two thousand feet above the plateau rim. Such a thick mass of ice probably required many years for melting. The Columbia River valley was occupied by the glacier for a distance of 20 or 30 miles. This ice dam effectively blocked the glacial melt water and formed a lake in the Columbia Valley to the eastward. As mentioned by Rollin D. Salisbury, 30 years ago (Journal Geology, Vol. 9, pages 721-722, 1902) this lake rose until it overflowed across the Grand Coulee divide near Steamboat Rock and the resulting mighty river and associated waterfalls excavated the Grand Coulee. The evidence for a long continued existence of a glacial lake consists of extensive areas of flat-lying lake beds called Nespelem silt by Pardee (U. S. G. S. Bull. 677). The largest areas of this silt occur between Nespelem and the Columbia River, up the San Poil Valley for 15 miles a little north of Keller, and in numerous terraces along the Columbia River upstream where erosion has not completely removed the silt. The Nespelem lake beds are generally well

stratified and consist predominantly of rock flour and other products of glacial erosion. It is proposed to call the body of water dammed by the Okanogan glacier, Lake Nespelem from the type locality near the town of that name. In order to overflow the Grand Coulee divide, glacial Lake Nespelem had to attain a depth of more than 1000 feet. After the Grand Coulee had been eroded to its present depth the lake was still probably 600 feet deep.

The whole of the Okanogan Highlands was covered by ice in the glacial period, except, perhops, for a few of the highest peaks. Inasmuch as the area is rugged and if we assume a fairly level surface for the ice cap, the glacier must have been quite thin on the mountains and thousands of feet thick in the Okanogan, Pend d'Oreille and other master valleys of the region. On melting, the ice must have disappeared first where it was thinnest on the uplands and lasted longer where it was thickest in the lowlands. The Okanogan Valley was filled with stagnant ice long after it had largely disappeared elsewhere. The absence of terminal or recessional moraine in the Okanogan Valley offers proof that the ice was not actively in motion. Besides the above negative evidence there is other positive proof in favor of stagnation; namely; (1) the elongated marginal lakes between the valley walls and the ice mass, the presence of which are known from lake beds, terraces, old outlets, and extinct river courses; (2) abandoned spillways used for carrying melt water when ice occupide the Okanogan Valley; (3) aqueous-glacial sedimentation that accounts for the large terraces of the Okanogan Valley which show kettle holes, ice contact slopes and fronts, and where dips in the sand and gravel generally dip away from the valley toward the spillways.

An outstanding feature of the Okanogan Valley is the great level terraces the highest of which is hundreds of feet above the river level. Those who first studied the topography of the region, Dawson, George Otis Smith, Willis and Russel, considered the terraces to represent temporary base levels followed by rejuvenation. Investigation shows, however, that the terraces do not have the characteristics developed by normal stream erosion. Terrace summits appear essentially level rather than sloping downstream. The front slopes of the terraces lack the smooth meander curve scars of river erosion but instead show evidence of having been in contact with ice. Large kettle holes, which resulted from late melting of blocks of ice surrounded by sediments, indent the level surface of the terraces. For example, kettle holes 100 feet deep are located in Wagon Road Coulee between Omak and Tonasket, on Tarheel Flat between Malott and Okanogan, and on Brewster Flat. Normal river terraces do not have such deep pits. Toward the larger valleys that drain the higher hills the terraces grade into alluvial fans, but aside from this their surface is more level than an ordinary river terrace. Since the glacier disappeared, remarkably little erosion of the terraces has occurred. The few gullies that mar the steep front slopes only accentuate the general lack of erosion. Lake beds of stratified silt or rock flour many feet thick usually occur near the terrace foot with beds of sand and water-sorted gravel composing most of the balance of the terrace mass. Many terraces can be traced into rock spillways at accordant levels. Terraces at different levels were developed in lakes controlled by separate spillways.

That abandoned stream courses were numerous in the Okanogan region was noted many years ago. Bailey Willis, (Changes in River Courses in Washington Territory, due to Glaciation, U. S. G. S. Bull. 40), described some of the old channels west of the Okanogan River as long ago as 1887. Dawson, Smith and Calkins also mentioned some of them, but the present writer believes that they erred in explaining the origin of the valleys. Essentially, the explanation was that the melt water from advancing and retreating glaciers combined with glacial erosion produced the effect. The writer considers that the plexus of abandoned channels can be explained best as outlets of marginal lakes along the stagnating Okanogan glacier.

When the Okanogan glacier stagnated it still blocked the Columbia River from below Pateros eastward for 30 miles. Pateros is at the junction of the Methow and Columbia rivers. Where the latter stream turns southward, a tongue of ice from the Okanogan lobe filled the Columbia Valley to Lake Chelan. After stagnation began the ice mass had retreated to within six to eight miles of Pateros, but it still blocked the Columbia Valley. A lake developed at Pateros with an elevation of 1300 feet. The terraces of this lake have their widest extent south of Pateros on Poverty Flat. Dotting the surface of this gravel terrace are dozens of potholes, of which at least ten are more than 100 feet deep. There are good indications of glacial ice contact. The water of this glacial lake found a spillway through Alta Coulee to Antwine Creek and thence to the Columbia which it entered at the level of the "great terrace" of the Columbia. Dawson thought this coulee to have been cut by a narrow tongue of ice, Russell suggested the canyon was a landslide rent, whereas Smith and Calkins explained the coulee as having been excavated by a marginal glacial stream, an idea concurred in by Aaron C. Waters (unpublished manuscript). Waters estimates that the coulee was eroded by flood water from an elevation of 500 feet down to a level of below 1200 feet A. T. Over the Columbia River from Pateros an abandoned channel about two miles long and 150 to 200 feet above the river cuts across the northwest corner of Douglas County. This served as a lateral channel when the Columbia Valley itself was still filled with stagnant ice. The drainage channels of Alta Coulee and the small canyon in Douglas County were probably the first episode in the story of the channel development.

The ice dam of the Okanogan lobe divided the melt water coming from the stagnant wasting ice. That on the west flowed into the Columbia as directly as it could, that on the east flowed into glacial Lake Nespelem and thence through the Grand Coulee to the Columbia.

On the west side of the Oganogan River the first marginal glacial drainage channels start at Brewster Flat. This is one of the most extensive terrace areas. It lies in the shape of an "L" about four miles east and west by five miles north and south. Several large potholes indent its surface which otherwise has an elevation of 1280 feet A. T. and is almost level. The terrace gravel has surrounded and buried an island-like hill of crystalline rock to within 200 feet of its top. Brewster Flat is nearly 500 feet above the Columbia and Okanogan rivers. Northward the flat narrows and a smooth steep-faced terrace a fraction of a mile wide continues three miles to the mouth of Davis Creek.

The first overflow of melt water occurred at about the 2000 foot level.

About 12 miles north of Brewster on Chiliwist Creek (about a mile from the Okanogan) there are large potholes and other evidence that the glacier rested over 500 feet above the river. The melt water backed up Chiliwist Creek into a basin two miles wide at Olema and then flowed southward over a divide at about 2000 feet elevation. It then continued down North Star Coulee to Brewster Flat descending meanwhile some 600 feet. Halfway from Olema to Brewster the channel divided and part of the melt water reached Brewster by flowing southwest into Whitestone Creek.

An abandoned channel southeast of the Okanogan starts on Chiliwist Creek two miles west of the river. The elevation of this channel is about 1450 feet A. T. The lower part is called Davis Creek. It temporarily served as a marginal channel.

The longest river channel used near the close of the glacial period extended from Okanogan northward through Spring Coulee, Salmon Creek, Lake Conconnully, Fish Lake, the dry canyon to Blue Lake, Toats Coulee, Loomis, Palmer Lake, and the Similkameen River into Canada. This channel, which is over 50 miles long in the United States, was first described by Bailey Willis. (U. S. G. S. Bull. 40). Side channels connect this major drainage route with the Okanogan River along Johnson Creek, also from Wagon Road Coulee via Mud Lake to Fish Lake, from Loomis via Spectacle Lake and Whitestone Lake to Aonasket, and from Palmer Lake to Oroville via the Similkameen Canyon. A minor channel connects Salmon Creek (near its junction to Spring Coulee) with Johnson Creek via Green Lake and Brown Lake and northward to Fish Lake. This channel was narrow and did not carry much water. The elevations of the divides were higher than in the large channel to the west and it therefore could not have been used very long or the divides would have been eroded to lower levels. Another minor channel extends from Spectacle Lake through Horse Springs Coulee to the junction of the Wagon Road Coulee and the Okanogan River.

Willis states regarding the major channel: "There is no question that the canyon is an old subaerial channel, very probably traversed by the Similkameen. One possible interpretation of the facts is that a glacier descended the valley and discharged through the several low passes eastward." However, all of these connecting channels are terraced and more than likely served to carry melt water from the marginal lakes in the upper Okanogan Valley. From Riverside almost to Canada the Okanogan Valley is little more than a mile wide. Inasmuch as the valley is 1000 to 2000 feet deep the glacier had great thickness and probably lingered long after stagnation. The first marginal lakes must have had a high level. The top of the divide in the major channel near Conconnully is about 2300 feet A. T., and the marginal lakes must therefore have been above that level. The Similkameen glacier that descended the abandoned channel also furnished melt water which used Johnson Creek, Salmon Creek and possibly Loup Loup Creek as outlets depending on which had the lowest divide and was first free of ice.

An important change in the Okanogan River occurred between Riverside and Tonasket. Before the glacial epoch the Okanogan River flowed through Wagon Road Coulee. When the ice stagnated there, of which there is abundant proof in pit lakes, in terraces with obvious ice contact faces,

etc., the melt water overflowed a divide on the east and eroded so deeply that the Okanogan River has permanently occupied the new narrow channel.

Farther east the most important channel extended from Omak and Okanogan through Omak Lake and Goose Lake to glacial Lake Nespelem along the Columbia River. A good sized lake existed near the town of Omak on both sides of the river. Pogue Flat, north of Omak and on the right bank of the Okanogan, was developed in the west marginal lake. On the east side of the valley vast gravel deposits interbedded with lake silts extend from Okanogan and Omak to Disautel 15 miles eastward. The principal terrace was developed at 1250 to 1300 feet A. T. the same as at Brewster Flat. Inasmuch as the old mission is built on a lake terrace this marginal glacial body of water might be named Mission Lake. Two channels carried melt water from the lake. The more westerly is the higher and was first used. Later the eastern channel via Mission was uncovered by melting ice and thus fixed the level of the largest channel formed in Mission Lake. From Mission the channel follows Omak Lake for eight miles to Boot Mountain, and passed on both sides of the mountain. The two channels around Boot Mountain unite at Goose Flat, a lake in wet seasons. From there the old river course continues on to the Columbia. The entire length of the channel from the Okanogan to the Columbia is 25 miles.

Minor lateral drainage channels east of the Okanogan are those of McLaughlin Canyon, which is four miles south of Tonasket, and of Soap Lake Coulee, which extends from the gravel terraces south of Okanogan City to the Okanogan River east of Monse. The channel resembles a cord stretching across a wide arc of the river. The north end of the channel is a narrow col with an elevation of 1700 feet A. T., but terraces along the gap indicate that it served as an outlet at a high level for the marginal lake until the lower Mission-Omak Lake channel was open. South of Soap Lake two outlets carried water to the Okanogan.

This study of glacial-drainage changes in the Okanogan Highlands is incomplete. Abandoned water courses exist between the Pend d'Oreille and Colville valleys and elsewhere. The author plans to continue and extend this study for another year. He hopes to complete a map that will show all of the ramifying abandoned glacial drainage channels of Washington north of the Spokane River and the Big Bend of the Columbia River.

Progress of Research In Silviculture In The Inland Empire[1]

R. H. WEIDMAN[2]
Missoula, Montana

SILVICULTURAL research in the territory embraced in eastern Washington, northrn Idaho and Montana began about 25 years ago with preliminary volume, growth and yield studies carried out by the first trained foresters to come into the region. In 1911 the federal forest experiment station for this region was established near Priest River, Idaho, and from the start a major portion of this station's activity has been devoted to silvicultural research pertaining to methods of cutting, thinning, reproduction, slash disposal, forest types and sites, and to volume, growth and yield. For about twelve years a research man on planting studies was assigned to Savenac Nursery. All this federal research in silviculture has been augmented by growth, yield, nursery and slash disposal studies by the forestry schools of the Universities of Idaho and Montana. In later years some investigations contributing to knowledge of growth and slash disposal have been conducted by the Western Forestry and Conservation Association and by the consulting forestry firm of Stevens and Bruce.

With regional research in silviculture covering this somewhat extended period and rather varied field of investigations, it will be desirable to confine this paper to a survey of the progress in this region alone. An attempt will be made to center attention on the research work and results that have contributed most to the solution of major silvicultural problems and to the advancement of forestry practice. At best it will be possible to touch only the high spots, the more important contributions to progress.

Naturally the most important silvicultural problem has been that of the proper methods of cutting and regeneration of stands in the various forest types of the region.

Because of the high commercial value and ecological complexity of the western white pine type, most activity has been devoted to it. Here is a coniferous forest type with six or more species in mixture with the white pine, most of them of little or no market value, most of them more shade enduring and more aggressive in reproducing themselves than the white pine. By virtue of its rapid growth and highly prized wood, white pine has from the start been the favored species for management in this complex type and against this formidable competition.

It is interesting to follow briefly the more important steps in methods-of-cutting research in this type. When the Experiment Station was established, clear-cutting and broadcast burning of slash was the practice on national forest timber sales. This was based on the belief of foresters at that time that white pine disseminated its seed great distances, as much as a half mile or more, and that the seed required mineral soil for germination. Brewster's early studies at the Experiment Station indicated quite convincingly that white pine seed traveled in sufficient quantities for adequate regen-

[1]Presented at the annual meeting of the Northwest Scientific Association, Dec. 28-29, 1932, Spokane, Wash.

[2]Northern Rocky Mountain Forest and Range Experiment Station.

eration only a few chains from the parent trees. These studies showed also that the seed germinated quite as readily in the duff covered forest floor as in mineral soil and that consequently destructive broadcast burning of slash was not necessary to successful regeneration. Both findings led to radical changes in the then prevailing methods of cutting and slash disposal with emphasis upon shortening of distances between seed sources and upon burning of slash in piles. Shortly after this Hofmann, who was then assisting Brewster at the Priest River Station, advanced the stored seed theory following studies made near the station. He based this on deductions that white pine seed retained its viability through a number of years of dormancy in the duff, and thereafter germinated upon receiving favorable light and heat through removal of the shade of the parent stand by cutting or forest fire. This plausible and interesting theory, correct in part only as revealed by later research, led to a return to virtual clear cutting with the precaution, however, of burning slash in piles in order to secure the maximum of reproduction from seed in the duff. Succeeding research by Larsen as well as results obtained on the existing timber sale areas led to the present seed tree method of cutting. The later research by Marshall, Haig and the writer has determined more exactly the distance of effective seeding, the size of seed trees and most significant perhaps the fact that the period of viability of naturally stored seed does not ordinarily exceed two years. The permanent sample plots of the Experiment Station are showing conclusively that under most conditions the greater part of the reproduction comes from seed trees rather than from stored seed.

The sample plots are yielding valuable results also with regard to germination and survival of reproduction. They indicate, for example, that 50 per cent of all the white pine reproduction that starts may be expected to die before it becomes three years old. The results show also that if a seedling gets through its third year safely it ordinarily becomes established. In this connection the most recent research of the experiment station is by Haig into the causes of mortality of reproduction. This consists of intensive installations of sowed seed beds on different soil and duff surfaces on clear cut, half-shaded and full-shaded areas, all subjected to careful instrumental measurement of air and soil temperature, soil moisture, humidity, evaporation and wind movement. Most interesting are the findings revealed by the soil-surface thermometers, showing that the small seedlings are at this point subjected to temperatures as high as 158 degrees Fahrenheit. Much mortality formerly classified as resulting from drought has been determined to be caused by these high surface temperatures. The general indication is that a moderate amount of shade is highly desirable to successful seedling establishment.

Another cutting problem in the white pine type, in addition to that of how to secure the desired reproduction, has been that of how to handle the unmarketable species which frequently are also highly defective. This problem has chiefly been attacked administratively by large scale experimental cutting by the Forest Service. Girdling of old and defective hemlock and also felling of all the inferior timber with consequent broadcast burning of the debris have been the two methods employed. The results to date indicate that felling and burning is the method to be followed where there is a chance to get white pine reproduction. Where there is no hope of getting the desired reproduction the indicated

practice is to leave the hemlock and other species untouched. In any case bodies of sound timber of the so-called inferior species are always left standing. Growth of residual stands containing white pine trees has been studied by the experiment station and data are available for forecasting rate of growth under such conditions. A notable example of methods-of-cutting experimentation by a private operator, and the only one in the region is that prescribed by Stevens and Bruce for the Clearwater Unit of Potlatch Forests, Inc. This is a high class carrying out of selective logging in the company's young, merchantable white pine stands of about 100 years old.

There has been little or no research in methods of cutting in the other forest types of the region. This has been due largely to comparatively small amount of national forest cutting in some cases, to relative ease of securing reproduction or leaving desirable reserve stands in other cases, and to lack of facilities on the part of the experiment station to undertake studies to any extent outside the white pine type. In the ponderosa pine type, however, the writer's early studies in Oregon and later observations here have supplied the ecological principles of regeneration and succession upon which are based a forth-coming publication outlining the minimum and intensive silvicultural requirements and practice for this type for the Pacific Northwest. It should be mentioned also that the Experiment Station this year conducted a selective logging study in the ponderosa pine type in western Montana.

Although slash disposal after logging is largely regarded as a protection operation, it is often equally important as a silvicultural practice. Larsen and Lowdermilk stressed the silvicultural aspects in their study of the subject in the white pine type. Fundamental findings and principles with regard to burning in piles and burning broadcast were enunciated. Answer was found for the first time to the puzzling question why reproduction some times followed broadcast burning and at other times did not, even though the burning came upon the hee'ls of an abundant seed crop. The explanation was found in the different moisture condition of the duff when fall burning was done as against that when the burning was done in the spring. In the spring the slightly damp duff with its contained seed was found to escape damage by the heat of the fire, whereas in the thoroughly dried-out forest floor conditions of the fall, both duff and seed were destroyed. Another noteworthy slash disposal study was conducted by Kempff as a member of the staff of the Idaho School of Forestry. This attacked the difficult problem of finding a less costly method than piling and burning which would be more attractive to the private operator, would satisfy the protection requirements and at the same time would preserve a maximum of residual trees and leave conditions favorable for the starting of reproduction. The method worked out by this investigation is reported to have been tried successfully on an experimental scale.

Volume, growth and yield studies were logically the first projects in the field of investigative work to occupy the attention of the early foresters in the region. To cruise timber for the purpose of determining his resources and for selling it, the forester must first of all have volume tables. In the very beginning of his plans for management he must also know something about rate of growth and yield, that he may determine the rotation and the annual cutting limitation for sustained yield. The earliest studies of this nature were made by the first technical foresters to come into the region and

their work was well done and satisfactorily served the purpose until later needs demanded greater detail and intensity of application. Among those who later contributed to what might be called the middle period of mensurational knowledge were Donald Bruce, Rockwell, Benson, Brewster and Whitney, working in the white pine, larch-fir, ponderosa pine and lodgepole pine types. Several years ago Behre as a member of the Idaho Forestry School faculty made an excellent and useful study leading to published yield tables of second growth ponderosa pine in northern Idaho. Watson and Nettleton of the same forest school staff made preliminary studies of second growth and residual white pine stands, respectively. White of the Regional Forester's staff at Missoula made preliminary studies of growth of residual stands in the lodgepole and ponderosa pine types. More recently Haig of the Experiment Station made for the white pine type the most comprehensive yield study that has so far been conducted in the region. This research has supplied detailed, normal yield tables for a wide variety of site conditions. It has produced also a large array of stand and other mensurational tables useful to the tasks of timber measurement and management. Among these should be mentioned particularly the first second growth volume tables to be made for all of the principal species growing in the white pine type. Also should be mentioned Haig's tables to aid in intelligently determining diameter limits, fixed or variable, in selective logging. Just this year the writer started a preliminary study of yield of second growth ponderosa pine stands in western Montana.

Research in artificial reforestation, i.e., in sowing, planting and nursery practice, was conducted on an intensive scale by the Forest Service over a period of about twelve years in this region. Both the Idaho and Montana Schools of Forestry have carried on some studies in nursery practice and to a lesser extent some in planting. Brewster, Larsen, Rogers and Kitchin, working both at Savanac Nursery and the Priest River Station, conducted the investigations which determined the best size and age classes of planting stock, the requirements with regard to seed bed preparation, season and density of sowing, soil cover, watering and shading. Wahlenberg, who worked at Savenac Nursery, followed the others and was engaged for a longer period in planting research than any one of them. He made perhops the most comprehensive studies and contributed most to knowledge of the subject, though he benefited a great deal by his predecessors' activities. His studies determined, for the nursery, proper fertilization methods and materials, corrective measures for nursery soil deterioration, and, most outstanding, chemical weed eradication to replace costly hand weeding. For field planting he determined the best lengths to prune roots for survival, he ascertained the factors that govern mortality and survival of field planted stock and, so far as possible, the measures to secure better survival. Most of this planting research was conducted in the white pine type where the great bulk of planting has been done. Much of this research was productive of results which led to improved nursery and field planting practice. Due to greater need of funds elsewhere, and the feeling that this research had supplied the current needs of administrative planting practice, planting research by the Forest Service was discontinued about five years ago.

There has been comparatively little research in methods of thinning, due to the feeling that the practical need for thinning was remote and the fact that funds were required for more

urgently needed research. Two small projects, however, are on the program of the Forest Service. One consists of eleven sample plots in white pine stands at Priest River, and another of about six plots in ponderosa pine on the Custer National Forest in eastern Montana. Available data on the white pine plots, which by units are now 7, 13 and 18 years old, indicate in a very preliminary way that to be effective in increasing total yield per acre, the thinnings must be begun fairly early, when the stands are not over 35 or 40 years old, and they must be reasonably heavy, although there is some danger of shocking white pine by too sudden exposure of crowns that have been growing in dense stands. Due to the small number of plots and their failure to include all the conditions to be considered, the present series cannot be expected fully to indicate the possibilities of thinning in this region.

Among other lines of silvicultural research in which some work has been done may be mentioned studies pertaining to forest types, phenology and the trial of exotic species. Time permits mention only of an investigation of forest types and the climatic factors that control them which was made by Larsen. This yielded data on the temperature, precipitation, frost and other climatological conditions prevailing for each forest type and also resulted in a map showing in some detail the types of the region.

Progress In Forest Fire Research[1]

By H. T. GISBORNE[2]
Missoula, Montana

THIS outline of progress in forest fire research is confined to the results obtained here in eastern Washington, northern Idaho, and western Montana. The period covered is relatively brief, as it was only twelve years ago that Larsen started the first attempts to measure fire danger, and Larsen and Delavan began the first analysis of fire and weather data for this region. When one looks back over this short period, and when one realizes that progress in any kind of research consists first of building up an oragnization to do the work, and second in getting results, it appears to me that remarkable headway has been made.

Today we have four agencies working directly on the problem of fire control and another contributing materially, if indirectly, as a by-product of other research. At the Northern Rocky Mountain Forest and Range Experiment Station we now have five men giving their full time, and from five to forty additional men temporarily used in various phases of this work. The Weather Bureau adds to this with almost all the time of one man, and with additional help in the form of instruments and the distribution of forecasts. The University of Montana contributes not only with the interest and efforts of the Dean of the School of Forestry, but also by providing laboratory space and facilities which the Experiment Station cannot furnish. The University of Idaho has been consistent in contributing research time by Dr. Hubert and several graduate students, as well as a large part of Kempff's time, with supervision by Dean Miller of the important

[1]Presented at the annual meeting of the Northwest Scientific Association, Dec. 28-29, 1932, Spokane, Wash.

[2]Northern Rocky Mountain Forest and Range Experiment Station.

project of slash disposal methods.

The indirect contribution, previously mentioned, consists of the time devoted by the Spokane Office of Blister Rust Control to the improvement of hand and back-pack pumps. Although fire control has benefited from this work, the time devoted to it cannot properly be called fire research. Roughly, therefore, we may say that the effort now devoted to fire research is equivalent to the full time of ten or twelve men, whereas twelve years ago there was only one man working only part time. This, in itself, is material progress for such a short period.

All of us, however, including the general public, are most interested in the results of this research. The only justification of this work is the production of results which will decrease the cost or increase the efficiency of forest fire control. While it is not difficult to point out these results, when you try to show the benefits, it is the same process as attempting to say how sick you would have been if you had not broken up that last cold just when you did. Ten or twenty years from now, when our fire records cover periods of several years use of research results, some other speaker will be better supplied with data than I am to demonstrate the monetary value of the dividends from this research. The best that I can do is to emphasize the most outstanding cases and to enumerate some of the many improvements in fire control made possible by the research for the past ten years.

Two of the most outstanding examples of dividends from fire research in this region can be credited to the Weather Bureau. One was the use of a forecast of wind direction which resulted in saving an entire mountain side and top from burning.

In this case the forecast of a change in wind direction was used by the man in charge of a large fire as the basis for a decided change in his attack. He moved his men to a section of the fire front which had been unapproachable and stopped the spread before it crossed a low saddle from which it would have quickly roared to the top of another mountain.

The other case was a special forecast of lightning storms sent to a Forest Supervisor. On the basis of that forecast that Supervisor moved some twenty men from construction work to smokechasing duty. As a result he was able to control over forty fires that peppered his forest late that afternoon and evening. Because he had these men in the right places before the storm broke, not one of the fires covered more than ten acres. If just one of the forty fires had been allowed to gain headway and blow up to a few thousand acres, as so many other fires were doing that year, the cost of control undoubtedly would have exceeded the total cost of all the fire weather research done by the Weather Bureau in this region to date.

These are only two examples of the benefits now being obtained from weather research done during the last ten years. Probably most of the state and private fire wardens, and I believe that every one of our 13 western Supervisors, could cite additional cases in which they have reduced fire control expenses and saved large areas from being burned by using the weather forecasts specially prepared for the forested areas of this region.

Although most of you appreciate the fact, I would like to stress the importance of special forecasts for the forested mountains of this region. We all know that the weather there and the weather at low elevation stations like Spokane, Lewiston, Kalispell, Missoula, etc., is so different that aaccurate forecasts for one will not apply to the other. If these differ-

ences are to be recognized in the forecasts, many stations must first be selected, equipped, and operated over a period of years to demonstrate the true character of the mountain weather. The installation and operation of over 200 stations for measuring precipitation, and some 20 to 25 quite complete meteorological stations in the mountains, which are providing the basic data for refining the forecasts, therefore, constitute real progress for a ten year period.

Closely allied with this work by the Weather Bureau is the Forest Service study of lightning storm occurrence and characteristics. Using from 150 to over 300 lookoouts as observers, we have found many facts concerning lightning not known ten years ago. The outstanding results of this work, which are used every season to improve fire control, consist of: (1) Determination that there are from two to four times as many lightning storms in the mountains as in the low country, hence a need of more forecasts of lightning in the mountains, (2) Data to help the Weather Bureau localize their forecasts of lightning, (3) Making the lookouts watch the storms more closely, and thereby producing quicker detection of lightning fires, (4) Determining the characteristics of storms, such as duration of rainfall and proportion of lightning striking the ground, which are typical of safe versus fire-starting storms, so that needed action may be taken even before the resultant fires are discovered. None of this information was available ten years ago.

Also included in weather research is the work of Dean Spaulding on long-time trends of rainfall. While we do not yet know enough to use such information, even in fire control, I believe that in the future all the long-time plans, the budgeting of expenses, and the financial justification of forestry, will have to be based upon these cycles of precipitation. And I believe that not only fire control, but also pathology, entomology, and silviculture will find such information fundamental to their success. Dean Spaulding's recent work, one study by Robert Marshall, and my own small efforts of several years ago, constitute the only work of this kind for this region. Nevertheless, today we know far more about these precipitation fluctuations than we knew ten years ago.

In measuring the forest fire danger, so that men may be more accurate in their determinations of current danger, we have several methods available today which the forest officer of ten years ago did not have. In those days every ranger, fire warden, supervisor, or other officer had to size up the many factors of fire danger for himself in order to determine whether he needed more men or less men. He still has to go through that process today, because just as the many automatic devices on modern steamships cannot replace seamanship or the judgment and experienced knowledge of the ship's captain, so there are no devices to replace the ability of an experienced forest officer to decide what should best be done to cope with any specific case of fire danger. But just as the modern sea captain makes full use of more refined measurements and many new devices produced by science for his assistance, so the forest officer today knows more accurately than ever before his current temperature, humidity, wind, wood moisture, and duff inflammability. Some thirty stations are now equipped with either wood cylinders, duff hygrometers, or both. These include stations in Glacier and Yellowstone National Parks, seven stations in Region 4, and the remainder on twelve National Forests in northern Idaho and western Montana. During the past season these forest officers

have also had a new device, the Fire Danger Meter, to help them integrate the effects of the several separate factors comprising fire danger so that protective action could be more consistent and uniform.

In this connection I should like to stress the progress made in this principle of fire control; the principle of using science as contrasted with the principle of rule of thumb practices. Ten years ago our forest resources in this region, valued at millions of dollars, were protected on the sole basis of opinion. When men *thought* that the danger warranted it, the protective force was increased. Whey they *thought* that the danger had passed, the extra force was released. Under such practices one ranger district or forest might be manned with only a skeleton force, while an adjacent district or forest, with similar danger, might be expending large sums for its full protective force. Regardless of whether these opinions were generally right or generally wrong, is such a principle of forest protection in accord with modern practices? Should a resource of such value be protected on such a basis of mere opinion and estimate, or should there be accurate measurement of each of the factors contributing to danger, a scientific integration of all these factors according to their relative importance, and a uniform policy of protective action based upon measured degrees of danger?

That is the basis for fire control now being put into practice on the National Forests in this region. While it is not yet fully applied, the present methods of measuring fire danger are the results of the research work done here, and constitute part of the progress. The daily use of these methods on the twelve most important fire forests, and their frequent use by the Regional Office to coordinate action on the various forests during the past several years, is the progress that I would cite. Ten years ago we had only unsupported opinion in fire control, today we have the full value of opinion more and more supported by scientific measurements.

There are three fire research projects conducted by the University of Idaho that fit into the picture here. Two of these, although relatively minor, were of fundamental use. One gave us our first accurate rating of the relative inflammability of four species of dead tree needles. The second gave us the ignition temperatures of the oils extracted from green tree needles of five local species. The value of such basic information is apparent to any scientist, and Dr. Hubert is to be commended for this work.

The third fire project of the University of Idaho is the slash disposal study. Although it is almost universally conceded that slash disposal is an essential practice in successful forest protection in this region, and even though this practice is both costly and often inefficient, no one except the University of Idaho has attempted to study the process scientifically. Although I have not seen a report on this work, I have been assured by others who are familiar with the details that the methods evolved can be applied to nearly all timber sale operations with benefits both to the cost and to the efficiency of the work. This is real progress in a most important field.

During the past two years two new fields for fire research have been attacked in this region. The first is the analysis of masses of fire records, much as the life insurance companies determine life expectancy for various age classes, occupations, health, and sex. We have had no such experience tables showing us the effect on fire control of past practices of discovery,

report, get-away, travel and searching, strength of first attack, reinforcements, etc., for each timber type. The second project is the scientific application of this information so that having the basic facts, this knowledge may be properly applied on the ground to produce the most efficient fire control at the least cost. If it is true that a science teaches us to know, and an art teaches us to do, then this last project may be more of an art than a science, but in this case the science is of not much value without the art.

The results of the first project—the analysis—are to be made available within the next two months. I believe that all agencies, private, state, and Federal, will find the data of value because they show practices by timber types so that the effect of various periods from discovery, report, get-away, travel, etc., can be determined for a specific timber type. Our past summaries were of no value for this purpose because they gave the data for National Forest units and therefore could be applied only to similar mixtures of types. The new data are being used almost daily in the reorganization of man power placement and facilities needed for successful fire control at minimum cost on the National Forests.

The second new project is the evolution of scientific methods of applying these particular basic data. For example, knowing the fire control objective that must be met in any particular timber type, and knowing the average rates of spread of fire during high, medium, or low infiammability, how many men should be available and how soon must they arrive at the fire to produce control before the lapse of the control time objective? Mr. Hornby has been able to reduce the answer to this complex question to a formula which reads: $a=c\left(\frac{4W-p}{4W+p}\right)$ In this formula a=the time from discovery of the fire to arrival of the man or men; c=the period from discovery to corral of the fire; W=the rate of held line construction to be expected from the number of men sent and in accordance with the resistance to line construction offered by the fuel type; and p=the rate of perimeter increase according to prevailing inflammability. The substitution of values for these factors and objectives results in the first table that I have ever seen showing the different combinations of speed and strength of attack that should guide the placement of men throughout a forest property in order to obtain satisfactory fire control. In my opinion this is a big step in advance.

This contribution by Mr. Hornby is fundamentally important in that it consists of a scientific method to replace the opinion, estimate, and even guess-work that have been necessarily used in the past. It is the function of science to find principles, and this formula, by integrating several component factors, describes the principle of speed plus strength of attack that is so fundamental to successful fire control. Many other similar methods have been produced by this research and it is this productivity of methods which reveals the true research character of the work. Whenever new and better *methods* are produced the contribution is not merely one of a job done, it is a new tool made available

to any user, and for all time—or until improved by some other researcher.

In summarizing, I would emphasize this one feature of our progress in fire research: that whereas only ten or twelve years ago the whole practice of forest fire control was based on the personal opinion and judgment of numerous individuals, today we are using scientific methods for registering and interpreting the natural sequence of events and conditions that constitute a fire problem. The rule of thumb procedure of the workman is being replaced by the recognition of principles and the accurate measurements of science. The science of forest pyrology is being born, to take its place beside forest entomology and forest pathology.

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NORTHWEST SCIENCE

DECEMBER
1933

Vol. VII Number 4

73
87

Published by
The
Northwest Scientific Association
Single Copy Thirty-five Cents

NORTHWEST SCIENCE

A scientific journal published quarterly by the Northwest Scientific Association and devoted to the dissemination and promulgation of scientific effort in the Pacific Northwest

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NORTHWEST SCIENCE

Entered as second class matter April 5, 1927, at the Post-Office at Cheney, Washington. Office of Publication, Cheney, Wash.

Published quarterly at a subscription price of $1.00 per year, which includes the membership dues of the Association. Non members $1.00 per year. Vols. I (1927), II (1928), III (1929), IV (1930), V (1931), complete, each $1.25.

Reprints of articles appearing in regular issues will be furnished to the author at the following rates, *provided they are ordered prior to the time of going to press.*

Pages	2	4	8	12
100 copies without cover	$2.50	3.00	5.45	5.95
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300 copies without cover	3.75	4.50	7.00	10.00
300 copies with cover		6.25	8.75	11.75

Printing of plates extra, at actual cost

NORTHWEST SCIENCE

Vol. VII DECEMBER, 1933 No. 4

The Association is not responsible, as a body, for the facts and opinions advanced in the papers published by it.

A Note of Appreciation to Those Entertaining Visitors to the C-2 Excursionists of the International Geological Congress

I wish to thank you for your contribution to the entertainment of the group of geologists who attended the 16th International Geological Congress, some of whom we were able to meet through Excursion C-2, numbering about 45 members and ladies from four continents and sixteen countries including our own.

As a last word the group charged me with the duty of thanking the citizens of Coulee and Spokane for the cordial reception and to assure them that the several events will be long remembered.

The opportunity of visiting Grand Coulee and of viewing the site of future hydropower development with the ultimate watering of a thirsty soil, captured their closest attention and admiration.

Should you visit the countries where these people reside they bespeak the privilege of returning in some measure your many courtesies.

Sincerely yours,

L. K. ARMSTRONG,

Member Organization Committee.

Peyton Building, Spokane, Wash.,

August 18, 1933.

Obituary

The death of Thomas Theodore Kerl on February 24, 1933, was keenly felt by the members of the Association and a large circle of intimate friends and co-workers.

Mr. Kerl received his early education in the public schools of St. Louis and Freemont, Nebraska, attended high school in St. Louis, and later graduated in law from Ann Arbor, Michigan. He then toured Europe for one year, taking post-graduate work in the University of Heidelburg, and after his return to this country took another post-graduate course in law at Harvard.

He became intensely interested in farming at this time, and with his accustomed thoroughness immediately began to fit himself for scientific farming by taking courses in chemistry and animal husbandry at Cornell, Universi-

ty of Washington, Seattle; Washington University, St. Louis, the University of California and the University of Idaho.

He continued his interest in soil chemistry, animal husbandry and physiological chemistry until the time of his death, through intensive study, not only on his own farming properties in the state of Washington and Nebraska, but also through travel throughout the United States, Mexico, Europe and even Soviet Russia, which he was enabled to do to greater advantage through his membership in the International Society of Soil Science.

These studies by no means circumscribed his activities. He was keenly interested in anything appertaining to the welfare of his fellow men; and his extensive travels and faculties of keen observation, coupled with a marvelous memory for detail and a gift of description made him a most charming host and sympathetic friend.

Reflections of An Argentinian on the Sixteenth International Geological Congress[1]

By

Dr. Carlos A. Morelli

THROUGH the exquisite courtesy of our conductor, Dr. Field, I am asked to express the gratitude which we feel when, in another section of the United States the members of the C-2 excursion organized by the International Geological Congress are received with so much deference by the citizens acting as our guides.

At my La Plata laboratory I received the first circular inviting me to participate in the Geological Congress and explaining the organization of these excursions; and so, having in mind the security with which North American institutions are arranged, I did not hesitate to associate myself with it, and when the time arrived I undertook the long journey which lead me more than 80 degrees from my country.

But I found another country, kindly and courteous, and the distance was lessened by the continuation of the same pleasant surroundings which sustain life. Here, gentlemen, I feel that I am at home and among friends.

When, during our daily activities, we receive from some distant colleague a letter, a subject for discussion, or a scientific contribution, the opportunity to clasp his hand or converse with him some day, seems uncertain. And so it is, gentlemen, that this excursion is more than a mere journey; rather, was a rare opportunity to know many workers in the natural sciences.

The presence of Dr. Smith-Woodward evokes a classic period for paleontology. He belongs to a group of paleontologists which includes Marsh, Cope, Ameghino, and Lyddeker which has done so much for the paleontology of the world.

The attendance of Dr. Stefanini brings to my memory the Pleiades of Italian scientists with whom I maintained a distant connection—Moiselli, Ficalbi, Mochi, Maggi and others—and the same courtesy and consideration distinguishes his conversation.

---

[3]Director South African Geological Survey.

The French mission recalls to memory my friends Marcellin Boule and R. Virneau, and as I notice its members observe and discuss, I feel they are worthy successors to the French geological science in which we Argentines have made use of the works of Lapparent, Houy and Mortensen.

The Belgian group, which contains notable men of science, is here with us. Some years ago there was discussed a problem having to do with the classification of an animal specie and it was necessary to have recourse to the Museum of Brussels because no institution of Natural History in Europe had what was preserved there. Dr. Wytenboogaart of Holland made use of the assistance of Professor Hustache of Paris, and Mr. Ball of the Brussels Museum compared the specie in the museum with the Boisduval types which were found for the first time in Australia more than 100 years ago—and the problem was solved.

Thus, gentlemen, the ideas, information and observations which we gather on this journey will not be lost and I am certain that many other views will evolve from them.

The South African representation headed by Dr. Hall[3], recalls another friend, Dr. Lounsbury of Pretoria, and it hardly seems possible that I can converse with him and not benefit by the culture of that continent.

Two Japanese naturalists are with us and they recall the celebrated Buntaro Adachi who, with his profund studies on the circulatory system, came to the conclusion that differences in the human race could not be established. And this is so, gentlemen, because Professor Tokuda has worked with us indefatigably, day after day.

Scientific men from distant people have come here guarded by your incomparable courtesy; you have shown us many things of interest in the different aspects of North American nature which are most remarkable—the great plains, the Grand Canyon, a few days ago Oregon, yesterday and today Washington, everywhere we have had authentic information from your scientists and we have been surprised at the interest of your youth and the enthusiasm with which the people of this great country follow the economic problems of geology.

Here in our circuit we reach the most northern part of the United States, and yesterday and today Dr. Allison was our guide, with the profound knowledge of his material made known to us in a few well chosen words the geological structure of Washington.

I drink to the good fortune of all present here, I am grateful for the cordiality with which the people of the Coulee received us, I hope for the happy continuation of this journey of study and for the happy return to his country of each one of our members. And I am sure that as these days with their interest and study fade in the past, more and more your kindness and courtesy will be remembered and I assure you that you will find a friend in each of us who has come to you from a far country, who will clasp your hand affectionately as he recalls these days.

Research Needs for the Future in Silviculture In the Inland Empire[1]

By
F. G. Miller
University of Idaho

THOUGH much has been accomplished in silvicultural research in Inland Empire, naturally the main task lies ahead. It is not my purpose to try to forecast it. In fact I do not intend to formulate a program of new projects at all, but rather to suggest a shift of emphasis to fields hitherto largely neglected.

Farm Planting

Silvicultural investigations in the near future should take greater account of the farm owner than they have in the past. These Inland Empire states, with federal aid, have all set up a service to assist the farmer in the establishment of woodlots, shelterbelts and windbreaks in the belief that such planting will be beneficial to him not only by the protection and products it will furnish, but also by helping along his program for diversified farming. Those charged with the administration of this very worthy enterprise may have a general idea of the trees best adapted for farm planting in the various localities but the information at hand is largely empirical rather than the result of experimentation. The sections most in need of farm plantings are those in the treeless belts and the species used must of necessity come from other regions. Whether these introduced trees will succeed in the new environment cannot be known until after they have been tried out. Since the localities vary so widely in soil conditions, elevation and climatic factors, the task of getting the information upon which to base reliable advice is one which must require considerable time. In Idaho so far investigations have been largely confined to black locust and its range for planting and cultural methods to use in growing it are fairly well determined. Similar investigations are being made for other species.

What species will succeed in the higher altitudes, or on alkaline soils, what aged stock to use, the relation of depth of planting to frost heaving and survival, what spacing to use for the different species, trees to grow in mixed planting, whether to plant in the fall or in the spring, can black walnut be grown from seed on the permanent site, should field crops be grown between the rows of young woodlots—these and mnay others are questions which are constantly received, and a type of silviculture which will answer them will be highly useful to a large number of people.

Nursery Practice

Many problems still in need of solution arise at the state nurseries where planting stock for the establishment of woodlots and windbreaks is grown. While nursery practice has silvicultural problems which are common to all nurseries, yet each nursery has its onw peculiar problems which must be worked out locally. In the Idaho state nursery the selection of soil for seed beds and cultural methods of growing seedlings have given trouble. Source of seed supply, depth to plant the seed, kind and depth of mulch to use, degree of shade to provide for the seedlings of different

[1]Read at the Ninth Annual Meeting of the Northwest Scientific Association held at Spokane, Washington, December 28 and 29, 1932.

species, methods of treating seed to hasten germination, how to prevent winter injury, methods of applying water to the transplant beds—these are some of the problems confronting us and which we are trying to solve.

Native Woodlands

Still another question of vital interest to the farmer is the proper handling of native woodlands so prevalent on the farms within the timbered belts of the Inland Empire. These either occupy tillable land which will later be cleared for agriculture, or are found on parts of the farm too steep, too stoney or otherwise off color for agriculture. The latter should be kept permanently in timber. The census for 1930 reports 4,554,054 acres of farm woodlands for Idaho, Montana and Washington. These are owned by 36,-151 farmers. The value of the forest products cut on the farms in 1929 was $5,165,396 or $143 per farm, a substantial increase to the family income.

These farm woodlands are of special value to their owners during this depression. I have had occasion to drive out among them some this fall. The owners are everywhere harvesting forest products. Some are cutting sawlogs, others pulp wood, posts, poles or ties, and practically all of them are cutting firewood. If they cannot sell the products for cash they trade them for groceries or other necessities, thus assisting themselves and their families to pull through the winter. This depression has created a desire to own these woodlands, though the owners feel the necessity of getting everything possible out of them without regard to silviculture.

The next step is to convince these owners that they can and should handle these holdings with a view to continuous income. Haig's[2] new bulletin showing the yield at different ages from second-growth white pine will be valuable to such of these owners as live within the white pine type, but there is the greatest need of demonstration plots in these farm woodlands of all types which will show the farmer how to harvest his forest crop without destroying his forest. Progress in conservative methods of cutting will be slow, of course, but the effort would be worthwhile.

As a start, the Idaho extension forester has now established several demonstration plots in farm woodlots in four different counties in northern Idaho. In each plot an improvement cutting has been made, the cuttings being used for firewood, the best trees of the plot being left. It is planned to make progressive thinnings periodically, the object being to demonstrate to the owner how he can get his fuel wood or other products and at the same time improve his stand. This is a crude and small beginning. The extension forester with the assistance of the School of Forestry will establish other plots as time and funds permit. At best our efforts alone will be wholly inadequate to meet the needs of the situation in Idaho, but I wish merely to call attention to the need of silvicultural investigations which will encourage better management for this class of forest holdings.

Little Used Species

In view of the present financial stress, it hardly seems possible that appropriations will come soon enough in sufficient amounts to protect all the white pine type from the ravages of blister rust. If not, then we shall need to turn to other species to replace white pine on considerable areas of marginal white pine lands. Mixed stands of Douglas fir, white fir, tamarack and hemlock make up most of the volume on these marginal lands and over other large areas mixed species with no white pine constitute the forest, so that

[2]Second-growth Yield, Stand and Volume Tables for Western White Pine Type, I. T. Haig.

it is certain that the wood working industries must depend more and more on them in the future. A publication showing the yield and stand of second-growth mixed types similar to that by Haig for the white pine type would be highly valuable.

In this connection, I am wondering whether cottonwood should not have a larger place in our silvicultural program than it has. I have recently been told that 10 to 15 per cent of the pulp wood used by the Inland Empire Paper Company consists of cottonwood grown in Idaho. The Everett Pulp and Paper Company at Everett, Washington is also purchasing Idaho cottonwood for its mill.

The introduction of species from other regions or even from foreign countries to take the place of white pine in part is worthy of consideration. Norway pine is particularly suggested. On account of the blister rust situation it is being rather widely planted in the Lake States to replace white pine. The Idaho School of Forestry plans to give it a trial under field conditions.

Residual Stands

The Clearwater Unit of the Potlatch Forests, Inc. is operating with a view to a sustained yield and their program is now some six years underway. Five years ago it employed a firm of consulting foresters to prepare a management plan for its guidance. The plan recommended and adopted is virtually one of selective logging by which the white pine is cut roughly to a diameter limit of 17 inches, and the mixed species to a limit considerably higher.

The result is a residual stand which presumably will yield a volume in about twenty-five years equal to the present cut. The objective is financial returns primarily rather than the best silvicultural practice. Nevertheless this is an outstanding example of private forestry, and one worthy of every encouragement possible on the part of foresters.

As cutting progresses there is afforded increasing opportunity for silvicultural research in a type of management which has attracted wide attention from other timber owners in the Northwest and which there is reason to believe will be adopted by other operators. Results of research here would, therefore, be of wide interest.

In the preparation of this paper, I wrote the manager of this company asking him what class of research data he would like to have, which is not now available. In his reply he especially emphasized the need of studies which would show the rate of growth and yields of residual stands of different densities and composition on the company holdings. This would mean the establishment there of a large number of carefully selected sample plots in the cut-over areas and the taking of periodic measurements on them. Growth and yield studies of residual stands would be of primary aid to other companies planning to adopt selective logging methods.

Natural Reproduction on Selectively Logged Areas

Another project the manager suggested would have for its purpose to show the relationship of shade density to the establishment of white pine reproduction under residual stands. Reproduction plots established in different densities of shade and periodic counts of seedlings would help to answer this question. But of more importance than a record of the abundance of reproduction is a knowledge of the causes which promote or hinder it. This would involve the setting up of various lines of ecological experiments to be carried on over considerable periods of time, yet the importance of such research is suggested by the fact that companies engaging in the practice of forestry are going to

depend largely upon natural rather than artificial reproduction for the renewal of their crops.

Soil Studies

Silvicultural research of the future will take far greater account of the relation of soil to the tree than it has done. It has been only a relatively short time since soil physics was given a place in agricultural research, yet in this brief period the soil physicist has contributed notably to the progress of scientific agriculture, practically every agricultural college now maintaining a department of soils.

In forest soil physics of the United States we stand today about where we stood in agricultural soil physics 30 or 35 years ago. Outside of what is being done by the forest schools at Cornell and Yale universities, we are doing little or nothing in the study of forest soils in this country. Yet I venture to suggest that soil science has potentially as much to contribute to silviculture as to agriculture. Forest soil maps and maps correlating forest types with soil types are important, but in addition soil studies should include analyses which will correlate the growth of forest trees with the physical and chemical properties of the soil. It is to be hoped that the organization of every forest experiment station and every forest school in the not distant future will include a department of forest soils.

Research Work Needed in Forest Entomology[1]

By

ELERS KOCH

U. S. Forest Service, Region One

I CAN approach this subject only from the postion of a layman. I am not an entomologist, but I have certain responsibilities in directing and planning the job of protecting the National Forests against insect attack.

In pursuance of this job there are many questions which arise, the answer to which would have important influence on the line of action taken. In the absence of such an answer we often have to proceed on the basis of an hypothesis which may or may not be correct, and if incorrect may result in entirely wrong action, often involving the useless expenditure of many thousand dollars or the loss of many million feet of timber.

The first group of questions pertains to the life history and habits of forest insects, particularly bark beetles.

What laws govern the spread of an infestation? In the case of a vast and destructive epidemic such as now exists in the lodgepole region, what causes it to start in the first place? Why do some epidemics reach a sharp crest and rapidly decline, while others seem to go on indefinitely? Does a great epidemic spread like a forest fire from a definite center, sending out advance small centers like spot fires. which then consolidate and are incorporated in the general advance of the main wave, or does the same mysterious condition which started a normal endemic aggregation of beetles to breeding furiously also operate at distant unconnected localities, so that there is no physical connection between one center and another? Can the whole lodgepole epidemic, which since 1911 has spread over the Flathead, Blackfeet, Kootenai,

[1]Presented at the annual meeting of the Northwest Scientific Association, December 28-29, 1932, Spokane, Wash.

Lolo, Bitterroot, Beaverhead, and Deerlodge Forests in Montana, over all the Central Idaho lodgepole region, and now threatens to swallow up the whole Yellowstone Park group of forests, and perhaps make its way clear down through Wyoming into Colorado; can this epidemic all be traced to one little group of insects that felt a primeval urge to increase and people the earth? It sounds incredible, but the fact remains that the successive waves of infestation can all be traced to expansion in one direction or the other of the older major bodies of infestation.

Is there any limit to this relation? When new beetle centers begin to appear in the Targhee or the Yellowstone Park 80 to 100 miles from the main Beaverhead and Idaho centers, are they independent buildings up of the local beetles, or did they all come in by long distance flight from the crowded multitudes in the Beaverhead? Is it possible that the successive waves of the infestation are not physical movements of the beetles themselves, but a successive progress of whatever mysterious condition it is that might permit the local beetles to take on an epidemic rate of increase?

I do not even pretend to know how to approach an answer to these question, but answered they must be before we can appropriate money for control work with any assurance that it is not hopeless.

Another phase of life history and habits that is shrouded in mystery is the selectivity of species. Mountain pine beetles will attack freely and destructively all of our major pine species, lodgepole, white pine, ponderosa pine, white bark pine or limber pine. If my observations are correct I can show you areas on which the beetles apparently swept through, taking out all the lodgepole and leaving the white pine almost untouched, and where a later infestation pretty well cleaned up the white pines. In the Kootenai the beetles are ravaging the lodgepole, are hitting the white pine to a much less degree, and are hardly touching the ponderosa pine at all. At the same time, in the Bitterroot the same beetle is moving down the valley with terrific mortality to the ponderosa pine. What is the relation to species? Will a lodgepole bred mountain pine beetle indifferently attack a lodgepole or a white pine, ore are there parallel epidemics of two strains of beetle? At the present time in Pattee Canyon near Missoula *D. monticolae* is ravaging the small ponderosa pine from 4 to 8 inches diameter, and at the same time *D. brevicomis* is hitting the big trees. Is there any relation between the two?

Here again we have a series of questions with an immediately practical application. We are trying, apparently with some success, to beat down white pine beetle damage on the Kootenai. Are we throwing away Uncle Sam's money so long as we cannot clean up the vast areas of the lodgepole attack? Do we dare even go into Pete Creek, right up against the edge of the lodgepole epidemic and try to save the white pine? If the Washington office would release the necessary funds, I would be rash enough to attempt it, but who knows?

No control job is one hundred per cent complete. Suppose we undertake control work on a dozen different drainages on the Coeur d'Alene forest. We clean up the bug trees to the best of our ability. A check up the next fall shows that on drainage A we have reduced the bug trees to one to thirty acres, on unit B to one tree to ten acres, and unit C to one in three acres. How can we tell where to stop? If we do no further work in unit A will the few remaining bug trees increase to three times the number next year, and three times that the following year,

so that we have the job to do all over again, or is there a point at which balance is restored and no increase will follow? There is no complete consistency. One unit may have one bug tree to ten acres, and, with no control work, shown no increase or even a decrease next year. Another unit, with control work, may show an actual increase next year. Do these insects all come from missed trees, or do they come in flights from another drainage?

Many of these questions can be answered only by repeated trial. The control work which has been conducted for several years in the Coeur d'Alene and Kootenai white pine may be considered primarily as an experiment. We try this thing and that thing, and by careful analysis of results may eventually arrive at a working scheme which will indicate what is possible and what is not possible in the way of control. The great difficulty lies in the impossibility of isolating all the factors. A certain control job is successful. The infestation is greatly reduced. Yet how do we know that natural causes might not have done the same thing? Presumably back of our empirical experiments we need to know the fundamental life processes and habits of the bark beetle before we can predict the probable natural development, and effect of artificial control in any infestation.

The method of approach to the answer to all the above questions I must leave to the ingenious entomologists to develop. A few of the fields that seem to be involved are:

Study of natural parasites and relation to epidemics.

Study of the vast number of questions relating to the life cycle of the beetles, such as reproduction, choice of host material, flight habits, etc.

A long continued study of the geographic progress of infestations.

Aside from investigations relating to life habits of insects, there is also a large field for study of practical methods of control work. A good deal of advance has been made on the job by practical men in the Bureau of Entomology and the Forest Service. For instance, in lodgepole beetle control we progressed from trying to peel trees standing to falling and peeling, then to decking and burning, and finally to burning standing trees with an oil spray. Much good work has been done in the way of developing equipment.

In the case of white pine control we are now up against a very concrete problem. Our most common practice in control work has been falling and peeling. We are now facing a doubt as to the effectiveness of this method. With the overlapping of generations, many beetles over-winter in adult form. We do not know how many of these adults are surviving the peeling process and escaping for new attacks. Possibly we are going to have to abandon the peeling method entirely and burn the log decks. There are also many questions to be finally answered as to the best technique in spotting and treating. Many of these questions are semi-administrative, but a study of methods could doubtless reduce costs and increase effectiveness.

A third general field of study is the economics of control work. This is dependent on results from the preceding groups of life habits investigations and control methods investigations. The sort of questions to be answered in this group are: How much are we justified in extending to control any epidemic situation? What would the probable loss be without control measures? What are the assurances that control measures will be successful? What is the relation between the cost of control measures and the prob-

able loss without control? What stages of infestation indicate control measures? Should we perhaps maintain a constant war on bark beetles and never allow an infestation to reach an epidemic stage? What will be the effect on fire control of the vast amount of dead timber created by insect attacks? What ecological changes in the forest will result from an extensive infestation? How much does our total annual insect loss amount to?

I have confined most of my remarks to bark beetle infestations, but there remain many other insect pests of importance. There is an aphis which is killing a large aggregate total of young white pine. There is the spruce bud worm which has ravaged vast areas of white fir, Douglas fir and hemlock all over Idaho. There is the pine butterfly, larch sawfly and other defoliators. There is the cutworm in the nursery, and a weevil in the base of the white pine. There is the whole field of wood-boring insects.

Most of the above mentioned insects, which are in the aggregate doing a lot of damage, we have passed up with a statement that we do not know any practicable means of control. Surely there is a large field for research in all of these species.

You will probably feel that my suggestions for a research program are indefinite. So they are. As I previously stated, I am no entomoligist. As a practicing forester I meet certain problems in insect damage and control. I have tried to state some of the questions which constantly arise to be faced. I must leave it to the entomologists to work out the lines of attack on these problems.

Progress of Research in Forest Pathology[1]

By

ERNEST E. HUBERT

University of Idaho

If I were to compare the progress of research in tree diseases with anything abstract I would say it is like the definition of deductive reasoning in that it has advanced from the general to the particular. Since 1896, the year when organized work in forest pathology was inaugurated in the United States, the earlier years were devoted to a survey of the tree disease situation with considerable emphasis upon the collection and determination of the organisms causing the disorders. From this general mycological study of the problem has evolved the more technical studies given over to a particular disease or a specific organism. The major work has been conducted by federal agencies, branches of which have been assigned such investigations as, the diseases of shade and ornamental trees; the study of epidemic types of disease such as the chestnut blight, the white pine blister rust and the larch canker; studies of the deterioration of wood products and studies of the diseases of nursery stock and of forest trees in general. A relatively minor portion of this work has been carried out by state organizations and private enterprise.

Many new organisms and several new diseases have been described since the inception of forest pathological work in this country. Of these there are several, such as the cull-producing heartrots and the epidemic rusts and

[1]Presented at the annual meeting of the Northwest Scientific Association, December 28-29, 1932, Spokane, Wash.

blights which are of major importance in the management of our timber stands. This period has also witnessed the invasion of our chestnut stands by the imported and very destructive chestnut blight and of our white pine areas by the exotic white pine blister rust. The losing fight against the chestnut blight taught us much regarding the rapidity of spread and the destructive power of an introduced disease and paved the way for quarantine regulations aimed at the exclusion of these damaging plant pests. During the fight against the chestnut blight a mass of information was secured regarding the causal fungus, its life history and its relation to the host plant, and the experience forced us to realize how hopeless this particular task could be. The white pine blister rust presented a different problem since we had here an organism that required two hosts in order to complete its life history. Contrasted with the chestnut blight it was found that control of the blister rust was not only an easier problem but could be depended upon when proper elimination of the alternate hosts, the Ribes plants, had been effected. The blister rust is still with us but persistent effort coupled with research work has presented us with the tools to fight back. The evolution of control methods in the blister rust fight is most interesting but it is sufficient to state that no single method is effective. New methods are constantly being presented, tested and adopted and we now have no less than six control methods classed under eradication and in addition there are the quarantine and inspection activities classified under prevention. Under eradication are now listed the following methods:

1. Removal of Ribes by hand.
2. Removal of Ribes by chemicals.
3. Removal of Ribes by combinations of (1) and (2).
4. Removal of Ribes by brush clearing or spraying followed by burning.
5. Removal of the entire brush cover along streams by means of bulldozers, followed by the burning of brush piles.
6. Reduction of Ribes population by means of forest management.

The list will not end here for already there are new ideas being hatched as new facts are turned up during the course of the work. The Division of Blister Rust Control has borne the burden of this tremendous task and to this Division goes the credit for the development of control methods. During the past decade a great many data have been secured on the life history of the rust, its damaging power, rate of spread, ecological relations, and meteorological requirements. Field studies have yielded important data on the host tree as well, information which was previously unknown. Field studies have also taught us that the old rule in research work still holds true—the behavior of an organism developing in a particular region changes with the invironmental factors of another region. The past few years have shown us how much more rapidly the rust spreads in the Idaho region than in the Atlantic states or in Canada and that in many cases a heavy infection of the crown of white pine can greatly hasten its death, since the longer time interval usually required for the rust to progress from the branch into the main trunk is greatly shortened by this intensified attack. The fact that the rust has found the conditions for rapid development exceptionally favorable in Idaho has made the task more difficult and has spurred the workers to greater activity.

Much progress has been made in developing control methods, yet hand in hand with this and contributing great-

ly to it has been the steady accumulation of data on the innumerable phases of this gigantic project. From the study of Ribes seed stored in the forest duff to the investigation of the pycnial stage of the rust and the part it plays in the life cycle of the fungus there has not been a single lead but what has received attention in an attempt to find new loopholes of attack.

Progress may be measured by the evidence that control areas examined in 1932 are free of damaging rust; the successful use of chemicals on *Ribes petiolare;* the development of field equipment for spraying, grubbing and bulldozing; new methods for surveying, classifying, working and checking control areas; ecology of host plants; discovery of stored Ribes seed in the duff; relative susceptibility data; cross fertilization by pycniospores; biological control of the rust; and the solution of many problems of coordination and cooperation, not to mention personnel and supervision.

Add to this progress a total of about 708,000 acres of white pine timber in northern Idaho, partially or completely protected, as the result of 5 years of control work and a thumbnail sketch of the blister rust program is complete.

The discovery of a new rust on pines in the Atlantic states, the demonstration of the function of pycniospores in certain rusts of flowering plants and the importance of the minute but critical relations between hosts and rust organisms have all been made within recent years.

Turning now to a survey of other fields we find that considerable progress has been made in the control of damping-off of seedlings in nurseries, the treatment of chlorosis in nurseries and the protection of seedlings and young trees against low and high temperatures. In one case it has been found that the use of certain fertilizers appear to favor the spread and increase the damage caused by damping-off. The speedy eradication of all known infected trees in the New England states during the past few years has apparently prevented the spread of a canker disease of the larch and other conifers which not only threatened the Eastern forests but loomed as a threat against our susceptible stands of Douglas fir in the West.

Improvements in laboratory and field technique covering many phases of forest pathology have appeared with increasing frequency during the past few years. The successful growing of rust fungi on leaves floated in nutrient solution, the direct infection of pine tissue with rust infected tissue, and the cross fertilization of pycnia are some of the more recent developments.

Perhaps the greatest development has been evident in the laboratory where decay and stain studies are conducted. Here we find new methods of testing the toxicity of wood preservatives and of the relative resistance of wood to decay; two new methods for protecting the joints of sash and doors against decay and stain; methods of preventing decay and mold in stored pulp laps; new and more effective wood preservatives; a new organic mercury compound effective in preventing blue stain in lumber; accurate laboratory methods for diagnosing decay in wood; new methods for combatting dry-rot in buildings; the discovery that the heartwood of certain trees contain water soluble materials toxic to fungi; data on the air-moisture conditions in wood favorable to decay; the discovery of chemical products producable by the action of fungi on wood; and a long list of additional achievements. Three heartrots of standing timber all appearing as white pocket rots and which have been laid at the door of *Trametes pini* have now been studied and as many different organisms have been found responsible.

A well-known wall-board and insulator manufacturer has been able very recently, through the aid of a specially equipped and manned laboratory, to water-proof, decay-proof and termite-proof its products. This is a step which we have advocated for the protection of wood and wood products during the past five years and it is hoped that the next five years will show still greater progress in this direction. The surprising thing is that so much has been accomplished in spite of unfavorable economic conditions.

The discovery of several new heart-rotting fungi and a knowledge of the part they play in the management of timber stands has also to be added to our list of achievements in forest pathology. The importance to the marking officer of reliable symptoms on the standing tree denoting the presence and extent of decay in the tree, has been emphasized by recent studies and considerable progress has been made through the revision of marking practice.

Some progress has been made in the solution of the decay problem as it relates to residual trees of the little-used species but the final answer is still in the offing begging for the inception of much-needed field studies. Several major studies of the decay in a number of commercial tree species, mainly conifers, have been made during the past 15 years. These studies have given us an insight into the rate at which the sound increment of a stand may be reduced. The average age of infection and the pathological cutting age have been determined for some six or seven species of trees, and the ease of detecting decay in standing trees has been greatly enhanced by data from these and related studies.

Much progress has been made during the past fifty years in finding the correct answers to innumerable questions regarding tree diseases, yet the future holds as many, if not more, questions of a similar and perhaps more complex nature. Since we must measure our milestones of progress in terms of economics and not always in terms of sheer scientific accomplishment, it is not a complete picture which I have tried to draw for you in this brief presention. We have, at least, gained a new respect for the damaging power of tree diseases, and though our losses may appear large[2], yet one important fact must not be overlooked; that by the application of known methods devised through investigative work conducted in the past few years it is believed that a very large percentage of our present annual loss in forest capital and forest products, totaling over 6 billion cubic feet, could readily be saved.

[2]Annual loss due to disease, decay, fire and insects equals 2.4 billion cubic feet. Annual loss due to decay and stain of wood products equals 4.0 billion cubic feet.

PROGRAM

of the

Tenth Annaul Meeting

of the

Northwest Scientific Association

December 27-28, 1933

Davenport Hotel — Spokane, Washington

REGISTRATION DESK

Mezzanine Floor, Davenport Hotel

PRESIDENT

H. R. Flint, U. S. Forest Service, Missoula, Montana

VICE-PRESIDENT

Thomas Large, Lewis and Clark High School, Spokane, Washington

SECRETARY-TREASURER

O. W. Freeman, State Normal School, Cheney, Washington

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Dr. S. E. Lambert, Spokane, Washington

A. A. Cleveland, Washington State College, Pullman, Washington

R. H. Weidman, U. S. Forest Service, Missoula, Montana

C. L. von Ende, University of Idaho, Moscow, Idaho

INSTITUTIONAL MEMBERS of the NORTHWEST SCIENTIFIC ASSOCIATION

University of Idaho, Moscow, Idaho
State College of Washington, Pullman, Washington
Whitworth College, Spokane, Washington
State School of Mines, Butte, Montana
State Normal School, Bellingham, Washington
State Normal School, Ellensburg, Washington
State Normal School, Cheney, Washington

LOCAL COMMITTEE

Thomas, Large, Chairman; L. K. Armstrong, E. M. Keyser, Ellis B. Harris, Dr. S. E. Lambert

MEMBERSHIP

Membership in the Association is open to anyone paying the annual dues of one dollar. Members receive, without additional cost, the issues of Northwest Science, the official publication of the Association.

HEADQUARTERS

The Davenport Hotel will be the official headquarters of the Association during the meeting and all general and section meetings will be held in the hotel.

REGISTRATION

The registration desk will be found on the mezzanine floor of the Davenport Hotel. All old members should register and receive their official badge for the meeting. At the same time they should see that their dues are paid. New members should fill out a membership card and pay the annual dues.

ANNUAL DINNER
Luncheon—Breakfast

The annual dinner will be held at 6:30 P.M. on Wednesday, December 27, in the Elizabethan Rooms. Reservation should be made at the time of registration. Price, $1.25. Members and guests are invited to attend. Ivan C. Crawford, retiring President of the Association, will give the address of the evening.

There will be a Sigma XI breakfast for members and friends on Thursday morning, December 28, at 8 o'clock in the East Banquet Hall. Reservations should be made at time of registration. Price seventy-five cents.

SCHEDULE OF MEETINGS
Wednesday, December 27

9:00 A. M.—Registration, Mezzanine Floor.

10:00 A. M.—General Session, Elizabethan Rooms A, B, C.

12:00 Noon—Open for luncheons of different sections.

1:30 P. M.—Sectional Meetings.
Botany-Zoology. Elizabethan Rooms B, C.
Chemistry-Physics. Elizabethan Rooms D, E.
Education. Room 200.
Engineering. Elizabethan Room A.
Forestry. Mandarin Room.
Geology-Geography. East Banquet Hall.
Social Science. Hall of the Doges.

3:00 P. M.—Medicine-Surgery. Elizabethan Rooms.

6:30 P. M.—Annual Dinner. Elizabethan Rooms.

Thursday, December 28

9:00 A. M.—Annual Business Meeting of Association, Elizabethan Rooms A, B, C.

10:00 A. M.—Sectional Meetings.
Education. Room 200.
Geology-Geography. East Banquet Hall.
Social Science. Hall of the Doges.

1:30 P. M.—Sectional Meetings.
Botany-Zoology. Elizabethan Rooms B, C.
Chemistry-Physics. Elizabethan Rooms D, E.
Education. Room 200.
Engineering. Elizabethan Room A.
Forestry. Mandarin Room.
Geology-Geography. East Banquet Hall.
Social Science. Hall of the Doges.

GENERAL SESSIONS
Wednesday, December 27

10:00 A. M.—Elizabethan Rooms A, B, C.
President H. R. Flint, Chairman.
Appointment of Committees.

1. "Natural Resources of the State of Washington," L. K. Armstrong, President, Washington Natural Resources Association, Spokane Washington.

Announcements.

2. "Some Observations on Educational and Research Institutions in Europe," H. A. Bendixen, Washington State College, Pullman, Washington.

6:30 P. M.—ANNUAL DINNER. Elizabethan Rooms.
President H. R. Flint, Chairman.
Address of Retiring President, Ivan C. Crawford, University of Idaho, Moscow, Idaho. Subject: "Science and Government."

Thursday, December 28

9:00 A. M.—Elizabethan Rooms A, B, C.
President H. R. Flint, Chairman.
Reports of Officers and Committees.
Election of Officers.

BOTANY-ZOOLOGY

A. L. Hafenrichter, Washington State College, Pullman Washington, Chairman.

H. C. Aase, Washington State College, Pullman, Washington, Secretary.

Wednesday, December 27

1:30 P. M.—Elizabethan Rooms, B, C.

1. "Growth and Development of the Deermouse" (Peremyscus maniculatus artemisiae), Arthur Svihla, Washington State College.
2. "The Ecology of Wallowa Lake," by Thomas Large, Lewis and Clark High School, Spokane, Washington.
3. "The Ecology of Umatilla County," J. Stanley Brode, Pendleton, Oregon.
4. "A Study of Ornamental Wild Flowers" (colored lantern slides), F. L. Pickett, Washington State College.

Thursday, December 28

1:30 P. M.—Elizabethan Rooms B, C.
Business Session.

5. "The Biology and Symptomology on Narcissus of Tylenchus Dipsaci Kuhn in Relation to Quarantine Regulations," C. R. Stillinger, As-

sociate Pathologist, United States Department of Agriculture, Spokane, Washington.

6. "The Ecology of 'Quincy Grass', Oryzopsis hymenoides, in Washington," by A. L. Hafenrichter and May Z. Huntamer, Washington State College.
7. "Problems in the Ecesis of Oryzopsis hymenoides, in Washington," by May Z. Huntamer, Washington State College.
8. "The Inheritance of Spring Growth Habit of Hope Wheat," by E. F. Gaines, and A. M. Schlehuber, Washington State College.
9. "Translocation of Organic Materials in Plants," by H. F. Clements, Washington State College.

CHEMISTRY — PHYSICS MATHEMATICS

Ralph W. Gelbach, Washington State College, Pullman, Washington, Chairman.
A. W. Martin, University of Idaho, Moscow, Idaho, Secretary.

Wednesday, December 27

1:30 P. M.—Elizabethan Rooms D, E.

1. "Metallic Soaps," William J. Shelton. 10 minutes.
2. "Thermol Dissociation of Butane," Otto Turinsky. 8 minutes.
3. "Application of the Method of Moist Combustion to the Determinations of Selinium in Organic Compounds," L. I. Gilbertson. 10 minutes.
4. Preparation of Hydrogen Selenide by the Interaction of Selenium and Hydrocarbon Materials," Clarence Green and W. E. Bradt. 10 minutes.
5. "The Determination of Transference Numbers by the Electromotive Force Method," R. W. Gelbach. 10 minutes.

Thursday, December 28

1:30 P. M.—Elizabethan Rooms D, E.
Business session.
Additional papers may be offered at this time.

EDUCATION AND PSYCHOLOGY

F. T. Hardwick, Whitworth College, Spokane, Washington, Chairman.
E. L. Hix, Spokane, Washington, Secretary.

Wednesday, December 27

1:30 P. M.—Room 200.

1. "The County Budget and Its Work," L. A. Lewis, Chairman, Spokane County Budget Committee.
2. "Subject Cost of the High School Curriculum," C. W. Stone, State College of Washington.

Thursday, December 28

10:00 A. M.—Room 200.

3. "Some Neglected Factors in Prediction Technique," I. N. Madsen, Lewiston State Normal.
4. "Character Training," A. C. Lemon, University of Idaho.
5. "The Work of the Mental Hygiene Clinic," Margery Heitman, M. D., Director.

1:30 P. M.—Room 200.
Business session.

6. "Seating Preference in the Classroom and Its Relation to Certain Variables," C. I. Erickson, State College of Washington.
7. "Personality Research," R. F. Hawk, Cheney Normal School.
8. Round Table Conference of Freshmen and other Tests at the College Level.

ENGINEERING

G. E. Thornton, Washington State College, Pullman, Washington, Chairman.
J. E. Buchanan, University of Idaho, Moscow, Idaho, Secretary.

Wednesday, December 27

1:30 P. M.—Elizabethan Room A.

1. "Laboratory Problems in Flood Control," J. G. Woodburn, State College of Washington, Pullman, Washington. 10 minutes.
2. "An Interesting Application of Chemistry to a Study of Underground Flow," James B. Fisken, City of Spokane, Washington. 20 minutes.
3. "Stream Pollution of the Northwest," I. Newton Carter, University of Idaho, Moscow, Idaho. 15 minutes
4. "Treatment of Boiler Feed Water at State College of Washington," Frank Candee, State College of Washington, Pullman, Washington. 15 minutes.
5. "Air Conditioning—A New Industry," H. C. Bender, Washington Water Power Company, Spokane, Washington.

Thursday, December 28

1:30 P. M.—Elizabethan Room A.
Business session.

6. "Federal Public Works Administration in Idaho," Ivan C. Crawford, University of Idaho, Moscow, Idaho. 15 minutes.

7. "Recovery of Gold From Placer Gravels," F. Cushing Moore, Consulting Engineer, Spokane, Washington. 20 minutes.
8. "Metallography of Alloys," Joseph Newton, University of Idaho, Moscow, Idaho. 15 minutes.
9. "Alcohol-Gasoline Motor Fuels," Harry Miller, University of Idaho, Moscow, Idaho. 15 minutes.
10. "Testing of Lubricating Oils at State College of Washington," H. H. Langdon, State College of Washington, Pullman, Washington. 20 minutes.

FORESTRY

F. G. Miller, University of Idaho, Moscow, Idaho, Chairman.
A. M. Sowder, University of Idaho, Moscow, Idaho, Secretary.

Wednesday, December 27

1:30 P. M.—Mandarin Room.

Accomplishments of the Civilian Conservation Corps

1. For the National Forests, Major Evan W. Kelley, Regional Forester, Region 1, Missoula, Montana.
2. For the Indian Reservations, Lee Muck, Assistant Director of Forestry, Office of Indian Affairs, Spokane, Washington.
3. For the State and Private Lands,
   (a) Montana, Rutledge Parker, State Forester, Missoula, Montana.
   (b) Idaho, W. A. Middleton, State Forester, Moscow, Idaho.
   (c) Washington, T. S. Goodyear, State Forester, Olympia, Washington.
4. For Blister Rust Control, S. N. Wyckoff, U. S. Blister Rust Office, Spokane, Washington.
5. For the Building of Men, Chaplain J. M. Gleason, Fort George Wright, Spokane, Washington.

Thursday, December 28

1:30 P. M.—Mandarin Room.

1. Business session.
2. "Forest Taxation," G. F. Jewett, President North Idaho Forestry Association, Coeur d'Alene, Idaho.
3. "The Lumber Code and Sustained Yield," C. L. Billings, General Manager, Potlatch Forests, Inc., Lewiston, Idaho.
4. "Fire Control in Recreational Timber Stands," George N. Paige, Chief Fire Warden, Glacier National Park, Belton, Montana.
5. "Past Trends in the Ownership of Forest Lands, M. H. Wolff, Assistant Regional Forester, Region 1, Missoula Montana.
6. "The Significance of the Effect of Crown Density Upon the Weather Beneath the Canopy," George M. Jemison, Junior Forester, Missoula, Montana.

GEOLOGY-GEOGRAPHY

E. T. Hodge, University of Oregon, Corvallis, Oregon, Chairman.
R. L. Lupher, Washington State College, Pullman, Washington, Secretary.

Wednesday, December 27

1:30 P. M.—East Banquet Hall.

Structure of the Northwest
(A symposium)

1. "An Unusual Underthrust Fault," C. H. Clapp, State University of Montana. 15 minutes.
2. "Basin Range Faulting in Idaho," Alfred L. Anderson, University of Idaho. 20 minutes.
3. "Epochs of Structural Development in Idaho," John W. Finch, University of Idaho. 30 minutes.

Thursday, December 28

10:00 A. M.—East Banquet Hall.

4. "A Plausible Cause of the Palouse Topography," W. A. Rockie, Regional Director, Pacific Northwest Erosion Control Project, Pullman, Washington. 15 minutes.
5. "Glacial Channels and Drainage Changes in Ferry, Stevens, and Pend d'Oreille Counties, Washington," O. W. Freeman, State Normal School, Cheney, Washington. 20 minutes.
6. "The Scablands of Washington," E. T. Hodge, Oregon State College. 30 minutes.

1:30 P. M.—East Banquet Hall.
Business session.

7. "Utilization of the Navajo Country," Albert B. Reagan, U. S. Indian Field Service, Ouray, Utah. 15 minutes.
8. "A Quadruple Glacial Valley in Central Idaho," D. C. Livingston, University of Idaho. 15 minutes.
9. "Tertiary Floras of the Columbia Basin," George F. Beck, State Normal School, Ellensburg, Washington. 25 minutes.
10. "The Occurence of Sphaerulites in the Acid Lavas of the Claro," W. D. Wilkinson, Oregon State College, Corvallis. Paper and abstract. 15 minutes.
11. "Some Features of Fine Gold," Thos. H. Hite, Consulting Geologist,

Moscow, Idaho. Lantern.
10 minutes.

12. "Factors in Ore Deposition in Belt Series Rocks and How Shall Research of Its Genesis be Directed?" J. H. Eby, Spokane, Washington.

MEDICINE-SURGERY

Open meeting of general interest.

Dr. R. F. E. Stier, Spokane, Washington, Chairman.

Mrs. Jacqueline Bahrenburg, Spokane, Washington, Secretary.

3:30 P. M.—Elizabethan Room.
Business session.

1. "The Crippled Child, a Liability or an Asset," Alfred O. Adams, M.D., Chief Surgeon of the Shriner's Hospital, Spokane, Washington.
2. "Some Early Doctors of the Northwest," Rev. Thomas F. Maher, S. J., Professor of Economics and History, Gonzaga University.
3. "Are We Russianizing Our Practice of Medicine?", W. A. Buice, M.S., M.D., Associate Professor of Bacteriology, State College of Washington.
4. "Do Your Endocrines Function Properly?", Dr. Frances Eastman Rose, M.D., F.A.C.S., Past President of Medical Women's National Association, Member of Washington Governing Committee of Gorgas Memorial Institution of Tropical and Preventive Medicines.
5. "Behavior Problems of Maladjusted Children," Very Rev. Charles E. McAllister, President of Board of Directors, Child Guidance Clinic of of Spokane.

SOCIAL SCIENCE

Claudius O. Johnson, Washington State College, Chairman.

C. J. Brosnan, University of Idaho, Moscow, Idaho, Vice Chairman.

C. R. Randall, North Central High School, Spokane, Washington, Secretary.

Wednesday, December 27

1:30 P. M.—Hall of the Doges.

1. "Present Trends in Representative Government," Honorable Burton L. French, Moscow, Idaho.
2. "The Influence of Migration on the Rural-Urban Balance," Prof. Fred R. Yoder, Department of Sociology, State College of Washington.

Thursday, December 28

10:00 A. M.—Hall of the Doges.

3. "Coordination in the Collection of Source Material," Mr. Charles W. Smith, Librarian, University of Washington.
4. "Nez Perce Trails," Professor Henry L. Talkington, Lewiston Normal School.
5. "Warren A. Ferris and Early Exploration in the Northwest," Dr. Paul C. Phillips, State University of Montana.

1:30 P. M.—Hall of the Doges.
Business session.

6. "Agricultural Financing Through the Farm Credit Administration," Mr. E. M. Ehrhardt, President, The Federal Land Bank of Spokane.
7. "The Twilight Zone in the Regulation of Public Utilities," Prof. Harry Chambers, Department of Economics, State College of Washington.

The Progress of Research in Forest Economics With Particular Reference to the Inland Empire Region[1]

By
M. I. Bradner
U. S. Forest Service, Region One

IN ORDER to present a clearer picture of the field for forest economic research in the solution of our forest problem, and to prepare the way for the discussion of the future needs for this type of research in the Inland Empire Region which follows, a brief discussion of the primary purpose and objectives of research in forest economics appears necessary.

The primary purpose of research in forest economics is to afford a satisfactory basis for a sound forest policy for the Nation, for the States, the forest regions, the forest industris and the private owner. In order to obtain the basic economic facts necessary to construct a sound forest policy, research in forest economics should include a complete survey or inventory of the forest resources of the United States, investigations of forest lands, including the relative value of the economic and social service which the land can render for timber growing, recreation, stock raising, water power, water supplies and other purposes; investigations concerning the economic aspects of forestry and related subjects, such as the costs and returns from timber growing, forest taxation, forest insurance, and in general of the financial feasigility of growing timber; of the relation of transportation of forest products to timber growing; and of the production, distribution and consumption of the products of forest lands.

Economic facts will, for one thing, indicate the effects of non-use of forest land and of timber shortages. They should indicate clearly the proper place, including both opportunities and obligations for public and private agencies in the general forestry structure. They should indicate, on one hand, the restrictions, if any, which the public should impose on private owners, and on the other hand, the aid which in justice the public should return. They should supply the necessary facts on requirements and potential growth in order that the entire timber budget for the nation and for each important product may be balanced.

Research in forest economics should perform invaluable service in furnishing a background for all other classes of research. It should in many cases point out the problems which are most acute and urgent. Forest economic research should also determine the financial feasibility of applying the results obtained in other classes of forest research. As an example, it should determine for the private owner the financial feasibility of forest management under the methods and potential yields determined by reasearch in silviculture and forest mensuration. It should tell him what his returns in stumpage or otherwise is likely to be as well as the probable costs of the mature crop. Beyond the mere acquisition of costs, this class of economic research should be constructive on such problems as forest taxation, insurance, and many phases of forest finance, organization and administration. There cannot be any question about the close relationship of research in forest economics with other classes of forest research.

[1]Presented at the annual meeting of the Northwest Scientific Association held at Spokane, Washington, December 28 and 29, 1932.

For the purposes of this discussion, the many investigations in forest economic research have been grouped under the five following general headings:

1. Forest Land.
2. Timber Products.
3. Other Products and Influences.
4. Forest Industries.
5. Forest Finance.

It is my plan to describe briefly the purposes and objectives of the type of economic investigations which fall under each of these five headings; to review the progress made in general on these subjects; and to discuss in somewhat more detail the work that has been or is being done along such lines within this region. Outside of the collection of statistical data, gathered in most part for other purposes, the work in forest economics research has been rather fragmentary and incomplete. The urgent need for investigations in this field of research has become evident in the number of projects recently initiated in this country. The greatest contributions to forest economics have been made by the Federal Government and the industries, although a large number of states have studied the requirements of their local industries. Only a few countries other than the United States have undertaken economic research through their research organizations. More has been done by individual investigators at the forest schools and elsewhere, and much statistical material is collected by the administrative branches in all countries with organized forest departments.

Inasmuch as the primary purpose of research in forest economics is to afford a satisfactory basis for a sound forest policy, and because most of the investigations that will be discussed in this paper are means to that end, this would appear an opportune place to make mention of a report now receiving the finishing touches in the Washington office of the Forest Service. This report, prepared at the request of Senator Copeland in a resolution presented at the last session of congress, finally resolved itself into a comprehensive plan of forest policy for the nation. Naturally the time alloted was so limited that further investigations were out of the question and the report had to be prepared on the basis of the best possible information and knowledge available at the time. There is no doubt but that this report contains much valuable information. Probably the most important result of the job has been to point out more clearly the problems which confront us and definitely set up the kind of investigations needed for their solution. A voluminous report covering this region was prepared by the Regional Office and the Northern Rocky Mountain Forest and Range Experiment Station of the Forest Service.

I. FOREST LAND

Investigations under the general heading of Forest Land include such studies as the economic and social significance of the use and non-use of forest land; land use in relation to forestry; the question of ownership of forest lands in order to insure supplies of timber ample for public requirements; and the classification of the land of the United States on the basis of its relative value for agriculture, timber growing, recreation, forage, and other purposes.

1. *General Progress*

Very litttle progress has been made in the solution of the important problem of land use. Some studies of the economic and social significance of the use and non-use of forest land have been made in certain localities in Michigan, Wisconsin and Minnesota by the Bureau of Agricultural Economics in cooperation with the State Universities of these three states. The Forest Service under a project entitled

"Land Use in Relation to Forestry" has made similar studies in Michigan, Wisconsin, West Virginia and California. Except for the meagre information from these few localities, we still have ahead the task of learning specifically what it will mean to have a timber-growing industry comparable to agriculture in its use of the land.

The Bureau of Corporations made a comprehensive investigation of forest land ownership about 20 years ago, primarily with reference to the bearing upon the public welfare of the concentration in a few corporations of the remaining stands of virgin timber, but with little bearing upon the problem of timber growing. Little in the way of analysis has been done, although the Internal Revenue Bureau of the U. S. Department of the Treasury has collected a large amount of data with tax returns. In periodic agricultural censuses the Bureau of Census also collects and publishes data on the forest land areas in farms.

Some land classification has been attempted in a very general way in a few states and most intensively and under the most comprehensive plan in Michigan.

This concludes the work that has been done, or is being done, in the field of economic research at large.

2. Local Progress

A few investigations have been made in this important field of economic research within the Inland Empire region. Dean F. G. Miller of the University of Idaho School of Forestry has recently completed a report covering the results of an economic survey of Benewah County in Idaho. This is a highly important piece of work and is an indication of one type of investigation that will be necessary in many other localities within the region.

The Timber Products Bureau of the Spokane Chamber of Commerce is responsible for a study now being carried on in Pend Oreille County, Washington, which has for its primary purpose the solution of the tax delinquency and land utility problem. The Forest Service is assisting the county assessors in collecting some of the necessary data.

Some information on tax delinquency in the five northern Idaho counties is also being collected and analyzed by the Region One Office of Lands under Mr. Wolff.

Studies of land values are at present being carried on in certain localities in north Idaho and northeastern Washington by the agricultural economists in the Agricultural Colleges of both Idaho and Washington State Universities.

II. FOREST PRODUCTS

Investigation in the field of Timber Products must obtain accurate information on available supplies, the drain by cutting, fire, insect and disease, the character and amount of the present growth, the requirements for timber products, substitutions, exports and imports, and the economic and social effects of timber shortages.

1. General Progress

The greatest progress in forest economic research in this country has probably been made upon the factors which make up a forest survey, the cut for various purposes, actual and potential replacement by growth, the effect of substitution and the area of forest land. A great deal of work has been done by both private and public agencies to determine the amount of standing timber, its kind, quality and distribution. With few exceptions, however, cruises or surveys of this kind have been local, covering only the holdings of a single owner or public agnecy and made under different plans and varying degrees of intensiveness for different standards of utilization by men of widely varying qualifications. State, regional or national sur-

veys or estimates of supplies have consisted almost entirely of compiling the results of these extremely variable local cruises. Up until recently the only national figures available were to be found in the so-called Capper Report prepared by the Forest Service in 1920. In 1925 the Forest Schools of Idaho and Montana in cooperation with the Forest Service in Region One compiled and published the only available statistics on the timber supply in the two states. In 1930, at the request of President Hoover's Timber Conservation Board, the figures in the Capper Report were revised on the basis of the best available information. This report, known as the Extensive Revision, is today the best and only information we have on the forest resources of the entire nation. It is obvious that the greatest and most insistent need at the present time is a comprehensive and detailed forest survey for the entire country.

In 1928 Congress authorized the Forest Service to cooperate with the states and private agencies in making just such a forest survey. Inasmuch as this is one of the most comprehensive and detailed surveys ever undertaken, it might be well to describe in more detail its objectives. The National Forest Survey contemplates a complete survey of the forest resources of the United States to determine the location, quantity and character of the various commercial timber species, present and prospective, including those now generally utilized or which may be utilized for the manufacture of news print and other important kinds of paper pulps; their availability for public and industrial uses; the amount and character of the present drain upon our forest resources, including cutting, losses by fire and diseases; and the character and amount of the present growth; character of timber and other forest products required annually for all domestic uses, together with the best indication possible of future requirements; and the area, location and condition of lands chiefly valuable for timber growth and the estimated periodic increases in voume that may reasonably be expected to occur on such lands under suitable systems of forest management.

Work on this project is now under way in several of the timbered regions of the country. The inventory phase of the survey has been completed for the Douglas fir region in Washington and Oregon.

Through reports by the Bureau of Census covering many years, and a much smaller number by the Bureau of Chemistry and the Forest Service, we have a reasonably satisfactory knowledge of the annual production and trends of production of lumber and most other wood products from our forests. For some such products as fuelwood and farm timbers, however, which are responsible for approximately one-half of the annual cut of all products, information is fragmentary and unsatisfactory. Of the actual drain upon the forest we know much less than of the material which is cut.

The Bureau of the Census has collected some information on the values and the requirements of the raw material for the output of the secondary wood-using industries. No information is available on the quantities of both requirements and output.

Three or four attempts have been made by the Forest Service to approximate the amount of current and potential timber growth for the entire United States, but these estimates have necessarily been based on rather fragmentary and unsatisfactory data. Much more complete and accurate knowledge of both current and potential productivity is essential to a real

appreciatio nof our timber situation and to the possibilities of meeting it satisfactorily.

One fairly comprehensive study of the entire situation of the substitution of other materials for wood was made several years ago by the Forest Service. The lumber industry, through its trade associations, particularly the Trade Extension Bureau of the National Lumber Manufacturers' Association, has done considerable work along the line of substitutions. Current changes, however, necessitate a constant attack upon the problem.

The Bureau of Foreign and Domestic Commerce has for many years supplied information on American imports and exports of timber and its products. These have been analyzed with reference to our general and detailed needs. Potential imports based on what is known of the resources of other countries have been similarly analyzed by the Forest Service. The whole question, however, is one that should receive fairly continuous consideration.

2. Local Progress

Vonsiderable progress has been and is being made in the Inland Empire region to obtain accurate information in the field of forest products. Field work on the inventory phase of the National Forest Survey was initiated in this region last field season. The work was started in north Idaho. Some work is at present being done on the requirement phase by the Section of Forest Products of the N.R.M. Experiment Station. The Forest Service in this region previously helped to get together the data on the forest resources of the nation used in the Capper and Extensive Revision reports by comgiling the figures for Idaho and Montana. The Idaho and Montana Forest Schools in 1925, cooperating with the Forest Service, Region One, Office of Products, collected, compiled and published in the Forest Handbooks for the two states the then best available information on Forest Statistics.

The Spokane Blister Rust office and the Coeur d'Alene Insect Field Station have furnished the only available figures on the losses in this region from the white pine blister rust and insects. The Forest Service, cooperating with the Forest Protective Associations of the two states, has currently collected and compiled the figures on losses by fire.

The Forest Service (Section of Forest Products of the N.R.M.), in cooperation with the Bureau of the Census, obtains by a canvass of all the sawmills in Idaho and Montana the annual figures on the production of lumber and shingles and lath. In odd years a canvass of all producers of forest products (includes besides lumber, hewed ties, mining timbers, poles, posts, pulpwood, etc.) is made. In addition to the amounts produced, information on the value of the product including the cost of manufacture, the stocks on hand and distribution are obtained. These data have been collected by the Forest Service since 1912 and provide the only source from which accurate data can be obtained on the amount of lumber and other products cut within the boundaries of each county in the two states.

III. OTHER PRODUCTS AND INFLUENCES

For some of the products of the forest, such as forage, upon which a part of the grazing industry depends, there is an economic field requiring investigations similar in its broader outlines to that indicated for timber products. The indirect influences of the forest, such as stream flow, soil fixation and climate, and such uses as recreation and water have important economic aspects which should be

understood, but on which as yet little or nothing has been done.

1. *General Progress*

The economics of the range livestock industry in general has been studied at various times by the Forest Service, the Bureau of Agricultural Economics, the Bureau of Animal Industry, the State Agricultural Colleges, and private organizations.

2. *Local Progress*

Very little work upon the economic aspects of these problems has been done in this region.

IV. FOREST INDUSTRIES

Separate forest industries and individual companies, those which cut or manufacture forest products, face a group of problems which fall more or less clearly under the designation of business economics. The group includes costs, returns, and finance in general; markets and marketing; competitive conditions and the economic side of such questions as operating efficiency, utilization and waste. Investigations are needed in the solution of the problems connected with the distribution of forest products. A thorough understanding of the relationship of the cost of distribution to the stumpage price of timber on one hand and to the wholesale and retail prices of the manufactured products, such as lumber, on the other, is a vital matter to the grower of timber in an understanding of potential profits as well as to the consumer who pays for the final product. The public and the industries need to understand the underlying laws governing changes and trends in prices. Prices of various kinds, on standing timber, on logs, on lumber at the mill, and at wholesale an dretail yards, and on some of the final products when collected and compiled over a long period of time are indicative of the trend.

1. *General Progress*

Studies of operating efficiency to get at underlying principles as a basis for the best plans of logging or other operations have been made by the Yale and Harvard Forest Schools and by the Forest Service. The Yale School has also worked on other phases of the business economies of the lumber industry. The Forest Service has made one thoroughgoing study of the business economies of the lumber industry.

Except for fairly comprehensive studies by the Forest Service and trade associations of wholesale and retail lumber distribution and of the volume of the lumber which goes to different states and regions, and those on the relation between stumpage and lumber prices and transportation costs made, or now being made by the Forest Service, little work has yet been done on the distribution of forest products.

The Yale Forest School has been studying lumber prices for a number of years. The Forest Service has also done some work along this line and is now collecting, in cooperation with the Bureau of the Census, and analyzing a very comprehensive set of stumpage price data from all parts of the United States.

2. *Local Progress*

The Western Pine Association last year adopted a program upon the recommendation of its Economic Committee (J. P. Weyerhaeuser, Jr., chairman) that contemplates the study of a number of problems in production control, marketing and transportation.

The Section of Forest Products of the Northern Rocky Mountain Forest and Range Experiment Station has conducted in the past a number of studies in the woods and mills of this region on the economic side of such questions as operating efficiency, utilization and waste.

Logging output studies have been carried on in this region by the Forest

Service since 1919. Logging output studies furnish information of a permanent character. Such data can be converted readily and accurately to a dollar or cost basis by the application of current wage scales, and costs, and are therefore a reliable means of estimating the costs of logging. As a result they find practical use in the appraisal of stumpage values, in bringing about efficient logging operations, and in determining sound and profitable utilization standards. Such information is a direct contribution to certain phases of the business economics of the lumber industry. The output developed by new logging equipment and new methods are studied as they come into use.

The Products Section of the N. R. M. Experiment Station also collects current prices on lumber, both wholesale and retail, stumpage, sawlogs, cedar products and ties. Most of these prices have been collected currently for a long number of years. Stumpage prices have been collected in this region since 1906. These prices have recently been compiled by years, showing the price of each commercial species separately for Forest Service, Indian Service, State and Private timber. Wholesale lumber prices obtained from the Western Pine Association under contract and compiled into quarterly and annual reports are available since 1913.

Detailed logging and manufacturing costs are obtained currently from practically all of the larger lumber companies in the region. These data are listed in detail, summarized by species and mill size groups, and averaged. This information is available dating back to 1919.

A number of market studies have been made by the Forest Service in past years. These include studies of wood requirements for the three large mining districts in Montana and Idaho and for five districts in eastern Montana.

V. FOREST FINANCE

In addition to forest taxation, the business of growing timber includes several groups of problems which can be answered satisfactorily only through economic research. These groups of problems can best be described under the heading of forest finance. The financial feasibility of growing timber is one of the most important of these groups. An important part of research in forest economics is to discover possibilities for private forestry. In more detail, this group of problems includes the cost of timber growing, questions of land valuation, credits and interest, forest insurance and forest taxation.

Forest taxation is an important element in the cost of timber growing. Research in forest taxation must first obtain data to show in detail the existing forest land timber tax situation and in more general terms the tax situation on other kinds of property. It must also give information on the place of forest taxation in local revenue. A second important class of information is needed to show the effect of the current tax situation on reforestation and timber growing.

In addition to determining the most of growing timber, there is a distinct possibility of reducing costs by greater efficiency to a minimum per cent volume of timber raised. Where it seems advisable to increase costs in order to increase quantity in yields, there is the possibility of determining the point of diminishing returns.

A third group of problems, which through its study of the kinds of timber which should be raised for highest profit, the sizes which should be produced under what length of rotation, relates the entire financial policy back to the underlying principles of silviculture and forest management.

1. *General Progress*

Some work has been done by the Forest Service in most of the forest regions on the financial aspects of private forestry. Selective logging studies have been carried on in the Lake States, the pine and hardwood regions of the South, the Douglas fir regions, the pine regions of Oregon and California, and in the Inland Empire regions. Firms of forest engineers have made similar studies in various parts of the country. Foresters with a number of the larger lumber companies have also carried on studies on the financial feasibility of timber growing.

With the exception of work in a few states, notably New York and Wisconsin, by the National Institute of Public Administration and the National Industrial Conference Board, respectively, and an investigation in New Hampshire, North Carolina, the Lake States and the Pacific Northwest, practically all of the consideration heretofore given to the vital question of forest taxation has dealt with theory and has been sadly handicapped by a lack of basic facts. Considerable work has been done, however, on the theory of forest taxation by the Forest Service, special forest tax committees, and the Michigan Agricultural College and other agencies.

A study to investigate the practicability and technic of insuring both old growth and immature forest stands is being made by the Forest Service in the Pacific Northwest.

2. *Local Progress*

Logging and milling studies to determine the production costs and market values for logs, trees, lumber and other forest products produced from each commercial timber type in the region were started by the Forest Service in the Inland Empire region in 1925. The final results of such studies are to shaw: (1) for the individual holding, the cutting limits (by tree d. b. h. and area) and utilization standards necessary to provide a reasonable profit and yet retain that balance between utilization and silviculture which insures a sustained yield of the desired timber products; (2) to make available to outside agencies data fundamentally useful in the development of industrial forestry; and (3) to make available information secured incidental to the main project such as overrun data, efficiency comparisons by logging and milling equipment, improved methods, etc. Studies of this nature have been made in the western white pine, ponderosa pine, and larch-Douglas fir types within the region.

The firm of Mason and Stevens, now Stevens and Bruce, has done a great deal of invaluable work on the sustained yield management problem within this region. The Western Pine Association under its manager, Mr. Dave Mason, has set up for study and solutio nby its economic committee the problem of production control. One of the solutions to this problem would be the establishment of sustained yield forest management through this region.

Mr. Jewett, general manager of the Rutledge Unit of the Potlatch Forests, Inc., has done considerable study on the forest taxation problem.

The greatest progress in research in forest economics in this region has been in the collection of timber products statistics including timber supplies and the cut for various purposes, and in the study of the financial aspect of industrial forestry. Most of the rest of the work is fragmentary and incomplete.

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NORTHWEST SCIENCE

MARCH, 1934

Vol. VIII No. 1

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NORTHWEST SCIENCE

Entered as second class matter April 5, 1927, at the Post-Office at Cheney, Washington. Office of Publication, Cheney, Wash.

Published quarterly at a subscription price of $1.00 per year, which includes the membership dues of the Association. Non members $1.00 per year. Vols. I (1927), II (1928), III (1929), IV (1930), V (1931), VI (1932), VII (1933), complete, each $1.25.

Reprints of articles appearing in regular issues will be furnished to the author at the following rates, *provided they are ordered prior to the time of going to press.*

Pages	2	4	8	12
100 copies without cover	$2.50	$3.00	$5.45	$ 5.95
100 copies with cover		3.75	6.20	6.70
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200 copies with cover		5.50	7.00	9.15
300 copies without cover	3.75	4.50	7.00	10.00
300 copies with cover		6.25	8.75	11.75

Printing of plates extra, at actual cost

NORTHWEST SCIENCE

Vol. VIII MARCH, 1934 No. 1

The Association is not responsible, as a body, for the facts and opinions advanced in the papers published by it.

EDITORIAL

One of our noted contemporary scientists has aptly summarized our present outlook when he stated that "In the past the world has suffered grievously from lack of knowledge; today it suffers from its rejection and misapplication. Could the springs of human conduct and the affairs of peoples be regulated only as wisely as we know how, there would be work and leisure and decent living for all."

As we face forward hopefully toward a new year of endeavor we must ever keep in mind that the rejection of painfully obtained knowledge and its willful careless misapplication may cause a setback in scientific progress so great that even centuries of work may be lost. Lost ground is difficult to recover: therefore careful planning should be our guide in steering the Association's course upon a troubled sea.

Let us first be jealous of the type of work we produce, whether it be teaching or serving; whether it be routine or stimulating; whether it be the highest type of research or the humblest of experiments. "By their works ye shall know them" applies to all walks of life and more so to that small band of workers which, because it is infrequently tied to industry, is as frequently regarded a luxury.

We should next look to our membership, consolidate it and increase it so that every worthwhile worker in science within our territory may be enrolled. Our newly elected officers have a plan for strengthening our membership which should receive the full support of all. Every scientific worker should be banded with us.

Full aid should be offered the Trustees in the furtherance of the worthy work undertaken by them. The industries of the region will progress no faster than their attitude toward research permits. The selling power of a product is based upon the improvements it can exhibit in competition with another product, and improvements can only be developed by the painstaking a c c u r a t e methods of science. The stimulation of research in the Pacific Northwest should be our aim.

Lastly, our official magazine should be given the support it deserves. Manuscripts and new advertising are its forms of expression. Without a means of expression the teacher and scientist is weaponless. Knowledge without dissemination is powerless, it must first be spread and humanized, and in order to be humanized it must be translated to the masses. Our sole means of expression lies in these pages. Let us make them vocal.

Service, the professional spirit of science, should be our motto in our relations to each other and to the masses which we serve, so that the era of "work and leisure and a decent living for all" shall not only come to pass but come to stay.

Coordination in the Collection of Source Material: A New Deal in Documents[1]

By Charles W. Smith

Librarian—University of Washington

BOOK collecting may not be generally recognized as the greatest game in the world, but hundreds of private collectors will contend that it is the most fascinating. Given a limited field to cover, an assured though moderate income, and a few appreciative friends, there is no limit to the pleasure to be derived from the pursuit of books. In what other avocation is there an equal challenge to the qualities of good sportsmanship—scent, daring, caution, perseverence—or a surer reward in the durable joys of possession?

Librarians as servants of the public may sometimes experience the thrills of the private collector of books. These thrills quite surely await the fortunate librarian who has the privilege of building a highly specialized book collection. But what can be said of the librarian in a public library whose duty it is to gather together uncounted masses of pamphlets, serial publications and heterogenous materials to be stored away against some possible use in the undated future? The contrast is certainly impressive between the private collector picking with nicety the choice items which he may wish to acquire and the drudging librarian who must dutifully secure every available item within assigned limits, without regard to condition format, or accessibility.

I do not wish to speak in derogation of the *play* of the private book collector. He stimulates the publishing and sale of books and the material which he brings together is usually made available for public use. I wish rather to commend the *work* of publicly supported libraries in collecting on a large scale for the present and future needs of the entire country. I wish, moreover, to take advantage of this occasion to outline the document-collecting program now being undertaken by the librarians of the state of Washington.

The program in this state is part of a nation-wide movement initiated by the Social Science Research Council and later taken over by the American Library Association. The work is directed by a Committee appointed by the President of the Washington Library Association and gives representation to the principal libraries of the state. The Departments of Sociology of the State College and the State University are also represented upon the Committee.

Activity began last spring with an investigation. Each of the larger libraries reported upon the following points:

1. The type of document material now being collected;
2. Additional types to be sponsored; and,
3. Types which each library was unwilling to sponsor.

A summary of the information received was presented at a Conference of the Association held at Victoria, B. C., on May 30, 1933. This information was informally discussed at the Victoria Conference and was later

[1] Presented at the annual meeting of the Northwest Scientific Association, Dec. 27-28, 1933, Spokane, Washington.

forwarded to the members of the W. L. A. Document Committee with the request for suggestions as to the improvement of the combined document resources of the state.

Replies received by the Chairman indicate a small amount of unnecessary duplication. What is far more serious are gaps remaining to be filled and the need for more intensive collecting. Each library has been asked to study its own needs and responsibilities with reference to the whole field of the social sciences. As in other cooperative programs carried forward by librarians of the Pacific Northwest, each library has been asked to define its own fields and declare its own aims. No obligations are recognized except those self-imposed for the general good of the whole group.

In planning the state program, the following categories of documents have been considered:

1. Official published documents of the state, and unpublished reports and records.
2. Publications and archives of semi-governmental or unofficial voluntary state organizations and agencies.
3. Local county and city official publications and records.
4. Local non-governmental or semi-governmental agencies, civic and social.
5. Newspapers.
6. Records of colleges and universities.
7. Records and publications of religious organizations.
8. Records of the industrial, financial and agricultural activities of the community.
9. Significant biographical material, including genealogies, family papers, letters, diaries, photographs.
10. Local histories, maps and atlases.

This is not the proper time or place to enumerate the action of each library with reference to the groups of document materials above itemized. A few general comments, however, may prove of interest.

1. The official published documents of the state are being generally collected by the principal libraries and are accordingly well distributed over the state. The primary collection is naturally at the State Library in Olympia.

2. Documents of semi-governmental and unofficial state organizations are sponsored by the Seattle and Spokane public libraries and by the State College and State University.

3-4. Official and unofficial publications of cities and counties are regionally collected, but a great deal more attention is needed with reference to these elusive groups. The public libraries of Seattle, Spokane and Everett together with the State College and the State University seem to have been the more active in the past.

5. Newspapers have and should receive regional attention, each town or city library assuming responsibility for its own papers. The State Library and State College are each collecting the papers of the whole state and accordingly collect many papers issued by communities having no public library. The collection of newspapers is being stimulated by the active work now in progress of reporting holdings for the *National Union List of Newspapers*.

6. The State College and State University collect the records of all colleges and universities of the state. Spokane and Tacoma report the collection of nearby institutions. Bellingham Normal school is prepared to assume further responsibility for this class of educational material.

7. The records and publications of religious organizations have not been adequately covered. Seattle and Spokane and the State College and University have been collecting for their several localities and regions. The College of Puget Sound is covering the Methodist church for the Northwest.

8. Records of financial, industrial, and agricultural activities should be collected on a more intensive scale. Naturally here again the emphasis should be upon regional collection. The State College has a special obligation with reference to the agricultural history of the state.

9. Significant biographical material, including genealogies, family papers, letters, diaries and photographs have been and should in the future be collected regionally, each town and city caring for its own history. Such material should also be sponsored by the State Library and the State historical societies.

10. Local histories, maps and atlases, representing original material of importance should be collected regionally, each library taking responsibility for its own locality. Categories 9 and 10 should be strongly centralized in a few strategic locations within the state. Among points worthy of consideration may be noted: convenience of access, i. e., nearness to centers of population; service to students, i. e., nearness to research centers, where scholars congregate; availability, i. e., with reference to publications and photographic reproduction. Historical manuscript material is unique and therefore more available if located where it may be readily photostated, or better still, where its importance justifies, where it may be edited and published in historical journals.

The Washington Document Committee has already discovered serious obstacles to the accelerated collecting campaign which it seeks to encourage:

1. A lack of information in regard to locally published material. One of its first concerns is the provision for some form of bibliography or checking list showing what material is being issued currently, the names of organizations, secretaries, and the like. Such a checklist would prove a most useful aid in exhibiting the field to be covered and directing the way to the material desired.

2. Inadequate budgets to cover purchases, binding and even the requisite stationery and postage involved.

3. A most serious handicap is that of inadequate staffs to care for the work of a collection program.

4. Not the least of our difficulties results from the wholly inadequate appropriation given to the State Library at Olympia. We cannot go very far in state library programs without the direction of some central official agency. The State Library is the logical agency to centralize and direct coordinated activity in Washington. We have a capable state librarian eager to do just such work, but without even the modest sum necessary to make a fair beginning toward such an undertaking. In most lines of educational advancement, Washington stands high. With regard to state directed library activity, it is near the bottom of the list.

Our strongest asset in the document campaign is a fine cooperative spirit. The organization set-up is being perfected and with the return of more prosperous days there is reason to expect that Washington librarians will have provided a broader and surer foundation for study and research in the social sciences. Teachers and investigators can give most substantial aid and encouragement by pointing out needs and materials, and by urging

upon institutions, boards and private individuals the importance of supplying public libraries with printed maerials and other records relating to their several institutions.

We not only have a fine cooperative spirit, but we are developing a technique of coordination which insures greater resources with an equal expenditure of money and effort. Other states have similar programs to our own and all considerable libraries of America will one day be tied together in a national network of information. The future scholar will have increasingly at his command the combined recorded data of the world.

The new spirit of coordination is the most promising aspect of modern library service. The service of the public library is altruistic and for this reason educators are asked to support every reasonable effort made by librarians to obtain for preservation and use all fundamental records of society as made from day to day. Libraries should be supported in so far as they are doing collective rather than individual work; are cooperative rather than competitive; stand for planned action rather than chance effort; seek to make their holdings available rather than inaccessible; acquire material for use not for show; collect accessible as well as scarce material and all material within self-imposed boundaries rather than the easy or attractive parts.

Section Officers Elected at the Annual Meeting December 27, 28, 1933

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Social Science—Chairman, Claudius O. Johnson, Washington State College, Pullman. Secretary, Charles R. Randall, North Central High School, Spokane, Washington. Vice-chairman, Paul C. Phillips, University of Montana, Missoula, Montana.

Dr. C. W. Hungerford, Plant Pathologist, Dean of the Graduate School, University of Idaho, and Vice-Director of the Agricultural Experiment Station, is on sabbatical leave. Part of his itinerary includes visits to a number of graduate schools in the United States. Dr. E. E. Hubert, of the School of Forestry, has been appointed Acting Dean of the Graduate School during Dr. Hungerford's absence.

Indian Emergency Conservation[1]

By Lee Muck[2]
Office of Indian Affairs, Spokane, Wash.

CONCEIVED and initiated during a period of unprecedented unemployment, deep down in the valley of an economic purgatory, the President's Emergency Conservation Program bids fair to attain a lasting place of high degree in the history of American forestry. Not as an emergency employment measure, in which it has accomplished much in the maintenance of the morale of the youth of the Nation, but as a major forward step in the practical application of the principles of conservation—namely, that well ordered procedure which seeks the preservation of land, water, forest and forage in a safe and entire state, promotes the conservative utilization of these resources for the purpose to which they were dedicated by nature and secures the full enjoyment thereof, today, without destroying the promise of continued enjoyment tomorrow.

The march of time will materially reduce the importance with which we now view the current unemployment problem and the Nation will soon forget the degree of accomplishment in the way of effective remedial measures in that connection upon the return of normal economic conditions. However, time in its progress will operate to materially enhance the value of constructive accomplishment in the field of conservation and the innumerable forest and land improvements which have been made possible by virtue of the Reforestation Act will stand forth as lasting monuments to a splendid idea—an idea which has sought and found the balanced coordination of men and resources to the end that both have been substantially benefited.

The Executive order of May 26, 1933, by President Roosevelt allotting $5,875,200.00 to the Indian Service for expenditure under the Emergency Conservation Act marked the dawn of a new day in the conservation of Indian forest and land resources. To the Indian people of the United States it opened wide the door of real accomplishment in the vast forests and undeveloped plains of his homeland and has made possible the permanent improvement of these valuable resources in a manner which has heretofore only been dreamed of.

Situated principally in the mountains of the Western States, the forests in Indian ownership are of both regional and National importance, and their future welfare is deserving of most careful consideration. These forest resources cover an area of approximately nine million acres, contain a merchantable volume of about thirty billion feet board measure, reflect a present fair value of some sixty millions of dollars, and command a dominant position as a source of raw timber products and as the conservator of extensive watersheds.

The vast range lands in Indian ownership are less significant from the standpoint of pure forestry. However, these areas which aggregate some thirty-five million acres, located principally in Montana, the Dakotas, Wyoming, Utah, Arizona and New Mexico constiute a major problem in Indian administration and have ac-

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1 Presented at the annual meeting of the Northwest Scientific Association, Dec. 27-28, 1933, Spokane, Washington.
2 Assistant Director of Forestry.

cordingly been given a prominent place in Indian Emergency Conservation Work. The programs in the non-forested regions have been almost wholly concerned with the conservation and improvement of range resources, the prevention of floods and soil erosion, the control of plant pests and disease, and the rehabilitation and reclamation of denuded lands.

Although the immeasurable forest values existing on Indian reservations and the importance thereof to the Indians and the people of the United States have for many years been fully appreciated by foresters, it is a strange fact that up to the passage of the Emergency Conservation Act little recognition in the way of adequate appropriations has been given to these resources. In fact, according to an article recently published in the Journal of Forestry by Mr. J. P. Kinney, formerly Director of Forestry in the Indian Service, "the funds available from gratuity appropriations, both for protection and administration, aside from those expended for fire suppression, have never exceeded $225,000.00 in any one year and have averaged less than $100,000.00 annually from the fiscal year 1910 to the fiscal year 1933."

As a result of this past policy of extreme economy, the Indian forests have not been improved or protected to the degree justified; adequate transportation systems have not been provided; lines of communication have been limited to an absolute minimum, and effective forest fire control has been seriously hampered. However, the constructive capital investment made possible by virtue of the reforestation act has materially altered the future development of Indian forests and opened wide the avenue of approach to effective forest management.

Just as soon as the Emergency Conservation Act was approved by the President, the needs with respect to Indian lands were vigorously presented, estimates of requirements were compiled and detailed working plans were carefully formulated. These working plans were laid down on a ground-work of intensive forest management—the general objective being to bring every acre of forest land to its highest state of production, secure a maximum growth under given conditions of site, species and rotation, and provide the greatest degree of safety from fire, insects and other destructive agencies.

It is the concensus of well informed opinion on forest management that the most effective approach to such an objective is through the application of sound protective measures and that real accomplishment in this field constitutes fully seventy-five per cent of the problem. Proceeding in accordance with this fundamental principle, the conservation program of the Indian Service, especially in the forests of the Northwest, has been largely concerned with the perfecting of an effective protective system, the construction of truck trails and fire lines, the location and erection of lookouts and the establishment of adequate lines of communication.

All major improvements have been built with a view to permanency and only after a most careful investigation of field conditions. Location surveys were conducted by a corps of skilled engineers and the work program has been prosecuted under the direction of a competent staff of trained foresters and practical woodsmen. A substantial percentage of the supervising personnel has been composed of trained Indians—men who have heretofore shown a profound interest in forestry and engineering and who are contributing a

full measure of constructive planning and service. All of these, combined with an enthusiastic group of Indian workers, were bonded together in a common cause and are pressing forward towards a single objective, namely, productive forests, properly safeguarded.

By the end of July 4,500 enrolled men were reported at work in eighteen states and at the end of September this number had been increased to nearly 12,000 or about 2,400 below the total quota of 14,400 which was authorized for the Indian Service as a unit. Approximately 75 per cent of the enrolled personnel and about 40 per cent of the supervisory force were composed of American Indians, men well qualified for work in the open and trained in the life of the woods. This experienced personnel, together with the organization of the size of the crews in such manner as to meet the demands of the character of work being performed, has assisted materially in the prosecution of the program and has produced a degree of efficiency which could not have been otherwise attained.

A general average of 2,200 enrolled men operating under the direction of 220 supervisors have been working in the forested areas of the Northwest District, namely, the Spokane, Colville, Yakima, Quinaielt, Makah and Tulalip reservations of Washington; the Warm Springs Reservation of Oregon; the Hoopa Valley Reservation of California; the Uintah and Ouray Reservation of Utah; the Duck Valley and Fort Hall Reservations of Idaho; and the Flathead Reservation of Montana. Making a possible exception of the Duck Valley, Uintah and Ouray, and Fort Hall, the reserves enumerated are more or less heavily timbered and as a result the conservation program of the Northwest District has been almost entirely confined within the field of pure forestry—a field of trees, living water and green places and one in which no end of unfinished business has long but silently awaited National recognition and attention.

The production activities of the Northwest Indian forests have been characterized by modern methods in construction without materially reducing the volume of manual labor available. Trail builders, tractors, graders, compressors and rotary scrapers have been allotted an important place in a balanced organization of men and machines; a dynamic organization which has written boldly across the pages of Indian forest history, blazed new trails into the wilderness and created a capital investment which bids fair to return a substantial income in new forest wealth, forest-minded Indians and real American dollars.

In brief review of the volume of work accomplished in the Northwest District, the following statistical information is of interest, namely:

1. Telephone Lines:
   - Constructed ..... 255 miles
   - Repaired ..... 150 miles
2. Truck Trails:
   - Constructed ..... 320 miles
   - Improved ..... 80 miles
3. Horse Trails:
   - Constructed ..... 120 miles
4. Roadside Clearing ..... 200 miles
5. Fences:
   - Constructed ..... 65 miles
6. Buildings:
   - Constructed ..... 35 units
7. Bridges:
   - Constructed ..... 95 units

In addition to this work, which is all more or less permanent in character, the Reforestation organization of the Northwest spent approximately 5,000 man hours in the control and suppression of forest fires and from

8,000 to 10,000 man hours on miscellaneous projects such as rodent control, the control of pine beetle infestations and the eradication of plant pests and disease. Much effort was also expended in the education and training of the personnel through discussion, demonstration and practical application in the field and although this policy probably resulted in some temporary reduction of efficiency in production, it has operated to materially strengthen the organization and will eventually return a full measure of value.

Up to the end of November a total of $813,190.13 had been expended in the prosecution of the reforestation program of the Northwest District, namely as follows:

Distribution	Amount	Per Cent
Salaries and wages	$355,976.32	43
Shelter	57,646.25	7
Subsistence	129,010.61	16
Camp equipment	30,465.55	4
Machinery, tools, etc.	86,915.90	11
Materials & supplies	90,585.38	11
Freight	20,906.93	3
Miscellaneous	41,683.19	5
Total	$813,190.13	100

Attention should here be directed to the fact that the percentage relationships reflected in an analysis compiled at this stage of the undertaking are more or less distorted by reason of the fact that expenditures for machinery, tools, freight, etc., will not be duplicated in the future and practically all disbursements will be confined to wages and subsistence. The ultimate relationship to be developed, with respect to direct labor's share of the total funds appropriated, will be contingent upon and directly proportioned to the period of time over which the program may extend. Inclusive of wages, shelter, camp equipment and subsistence expenditures to date indicate that the reforestation personnel has received the direct benefit of approximately seventy per cent of the moneys disbursed and it seems safe to conclude that a relationship of eighty per cent will be developed in that connection by the end of April, 1934.

During the month of November the Indian Service received a further allocation of $4,000,000.00 for the continuation of the Emergency Conservation Work to April 30, 1934, and although some of the camps in the higher altitudes have been abandoned and the character of the work altered, the number of men employed has not been greatly reduced. The splendid weather experienced thus far has assisted greatly in the maintenance of a normal degree of efficiency and unless serious conditions develop during January and February, our forest improvement activities will be continued throughout the winter without serious curtailment.

The Indian people have been deeply interested in the program since its inception and have taken every possible opportunity offered in obtaining a knowledge of practical forestry. Arrangements have been made for the operation of several training camps during January, February and March in which selected Indians will be trained in the elements of practical forestry, erosion control and range management. The leader camp for the Northwest District will be located at Fort Simcoe, Washington, and we wish to take this opportunity of soliciting the interest of the group of educators here present, with the hope that we may secure your active assistance in this new movement in Indian education and in the advancement of the art of forestry on Indian reservations.

Some Games by the Northern Utes

By Albert B. Reagan

Indian Field Service, Ouray, Utah

PRACTICALLY the only game played by the the Northern Utes at the present time is "cards." In this they have a game of their own which is not well understood by the whites, though our cards are used. From mere observation, it appears that stakes are placed on each card put down and the money raked in as soon as it is placed. The native games, so far as known, here follow.

The "Up-Jinks" Game

In this game the Indians sat in a ring, but were divided into two sides, with a pile of money and sticks between them. The sticks were the game sticks. One side would pass a stick between them, chanting loudly in a monotone all the while. A player of the opposite side would point his finger and grunt at the person whom he thought had the stick. If he were right in his judgment he was given the stick which later could be pawned for the money. It might be added that this was probably a variation of the next game to be described.

The Hand Game

This game was extensively played formerly and large stakes were placed upon its success. The prerequisites among the Uintah Utes were four highly polished, slender bones, each of about three and one-half inches in length, two of which had a strip of leather wrapped around their respective middles; while the Yampa Ute used two cylindrical dice of about two inches in length and an inch in diameter. These were highly polished bones, one being white and the other colored in black, or sometimes ornamented with black band, the latter being known as the mystic or winning dice. These dice the writer will here call game-sticks. The other requisites were two bundles of sticks. If among the Yampa Utes, each of the sticks was pointed at one end and the bundle was set upright with the sharpened end of the sticks stuck in the ground. Among the Uintah and Ouray, the bundles were placed flat-wise on the ground. The sticks of these bundles will here be designated as counting sticks or just counters. When playing the game the player held a game stick in each hand, placed one above another, allowed the upper one to pass into the other hand with the other game stick, placed them behind his back, under a blanket or behind an apron (if the player was a woman) or at any place out of sight of the guesser, his opponent, though he faced that person in the open throughout the whole time he was playing. When playing, the players, were two in number and sat opposite and about six feet from each other; or if the game was played in a tent or a house, they sat on the opposite sides of same, each player usually being joined by many helpers who sat abreast with him. In this game the player, having changed the game sticks to suit himself, as given above, brought his hands before him and swung them back and forth from left to right and the reverse as he changed the sticks in sight or out of sight (concealed) from hand to hand by sleight-of-hand performance to disconcert his opponent, as his colleagues sang a vigorous

song, the syllable "ah" being pronounced in a whining, nasal tone for every note to the time beat on a rude-parchment-covered drum among the Yampa Utes, and by beating a horizontal pole with two sticks among the Uintah and Ouray Indians. A "good" player would change the sticks after the guess was made. As the player was thus acting, the guesser was preparing to make his guess. He made false motions with his hands. He hugged himself tightly by crossing his arms and placing either hand under the opposite arm and, with a dancing motion of his body, swaying to and fro and from side to side, watched the shuffling of the sticks with the closest attention. He pointed to this hand and then to that of his opponent while he argued and joked to see if he could decide from his actions where the valable stick was, in which hand it was held. He then made his guess (called it) by slapping his hands together in a vigorous manner and then pointing his right hand toward his opponent's hand he had decided held the marked, mystic, winning stick. As he struck himself under that arm with the other hand, he pointed to his rival's hand to be opened. If he won, the sticks were turned over to him. If the mystic stick was not in the hand he had designated, he forfeited a counter which was taken from his bundle of counters. (It is said by some of my informants that in playing the game among the Yampa Utes, both of the gamesticks would be found in one hand of the opponent, and the guesser had to guess which hand they were in, or lose.) When all the counting sticks had passed to the possession of either of the contestants, that side had won.

The Ute Stick Game

This game is called Toruk-we-nup (game sticks) by the Utes, and when one wishes another to play it with him he says, *"Pie-yuke-kee toruk-we-nup* (come, or let us, play the game sticks)."

In playing the game a square "game board," (fig. 1) ranging from two to three feet to a side, is used. This may be made of lumber, cloth or buckskin, the latter being the kind of "board" used in the old times. Around its margin the count-characters are painted, as projecting triangularly topped "posts," in stockade-style, of from three to four inches in length, projecting inward from a dark marginal line near the edge of the board. These posts are called *neah-po-kut* (comb marks); while the blue posts with yellow tops are individually called *saw-waah,* and the red ones with blue tops, *a-gaaht...* Each side of the board carries two segments of these count-characters, of fifteen posts each, which are separated by a wide space at about the middle line of that respective side. The posts are painted by fives, with differently painted tops, though the colors seem to be of no other purpose than to please the eye. In one of the wide spaces there is a concentric-circle-topped figure which is called *weem-weep.*

It is the starting place in the game. On the opposite side of the board from this figure there is a variously colored cross. The other wide spaces contain no figures; but a three-lobed leaf (flower) corners each of the inner corners of the space within the count-character decorated border, figures which are for ornament only. A ring of three or more inches in diameter marks the center of the board. On this a flat rock is placed which is used as the bouncer of the hurled gamesticks. The game or throwing sticks are four per set, two, three or four sets being used in playing the game, each set containing four halves of

small sticks of about a foot in length These sets are differently painted on the split-face sides so that one player's set can be readily kept separate from the sticks of the other sets. Otherwise they are similarly marked, the round faces being unpainted or painted white. Each stick has two half black-rings transverse of the round-face, near each end; while the major (magic) stick of each set has a butterfly figure clasping the round face in about its center, longitudinally. This figure is called *no-go-kwat* or *wa-e-sin go* (no) *kwat echiwennie*. This stick also has a criss-cross, zigzag lightning figure (or just diagonal cross-bars) cut on its split face which is usually painted black, if that face itself is not painted black. The white or unpainted side of the respective sticks is called *saki* (*sa,* white); the red painted side, if so painted, *ne-ka-at;* the black painted side, *too-kwat* (from *to-ka,* black); the yellow side, oa-yah-kot (*kwot*) (from *oa* or *yah,* yellow).

In playing the game, if there are but two players, they sit opposite each other with the game board between them. If four play the two to the right of the starting point and the two to the left of it are partners; and in playing they play in opposite directions from the starting point. Before playing they deposit the stakes, usually money, under the center stone. When playing, the contestants bounce their game-sticks endwise on the center rock, the sides up when they fall within the count-character border determining the counts gained with a respective throw. Below are the rules

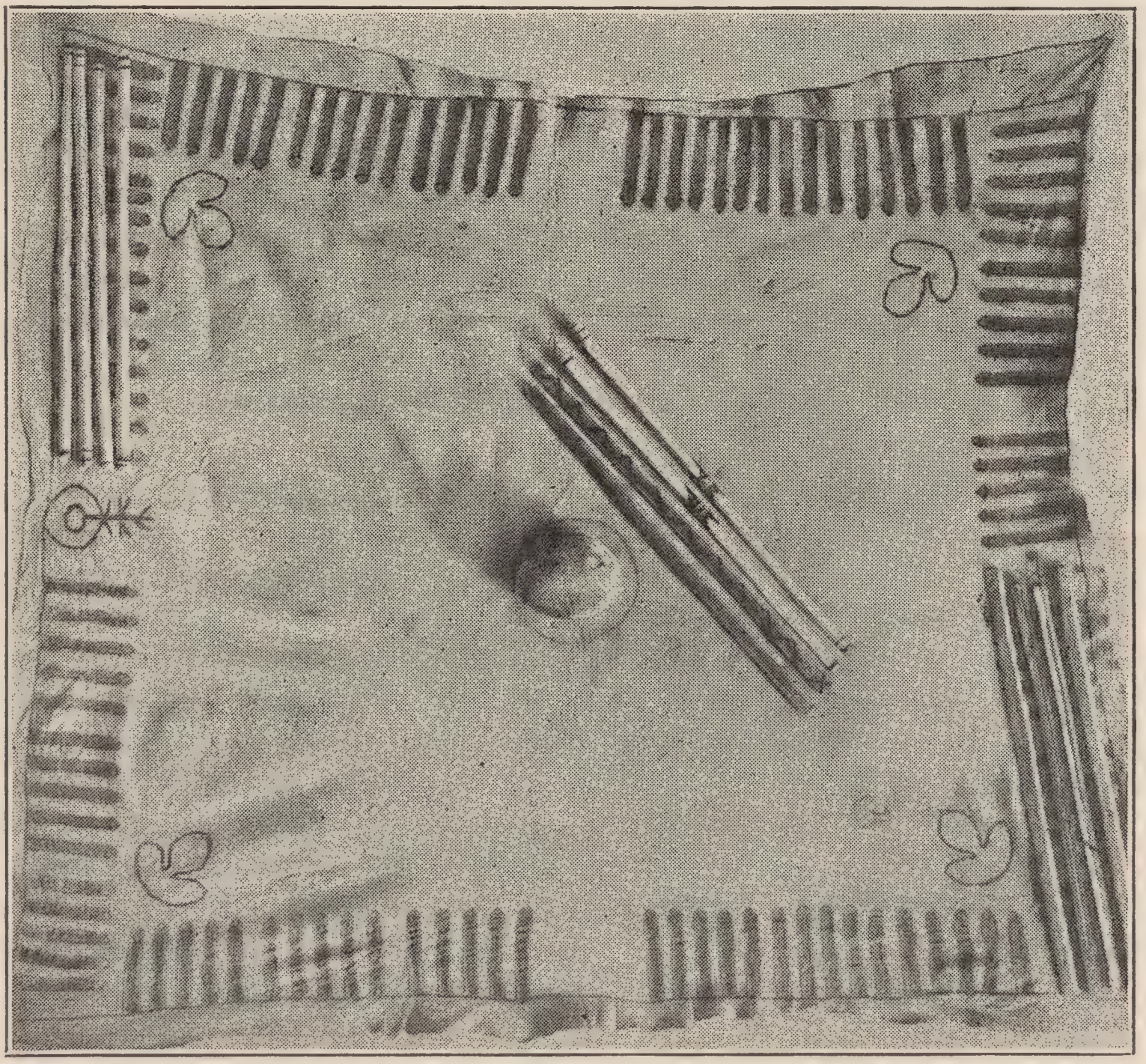

FIG. 1—The Ute Stick Game, showing the ornamented buckskin, the rock in the center and the three sets of sticks.

for playing the game, with the white-yellow sticks.

All yellow faces up counts the thrower 5 points; two yellows up, 2 points; all white sides up, 10 points; three yellows and white side of the marked, yellow-side one, or butterfly side, up, 9 points; three whites and marked yellow side one, 10 points; one white, three yellow sides up, one of the yellow sides being the lightning-marked one, 4 point; three whites and one yellow up, 3 points; one white and three yellow ones (not including the one with the marked face) up, 1 point. The other sets of sticks are similarly used, except red or black sides, instead of yellow, are considered in the counts, as they are thrown up or down in the caste.

The counters now used in playing this game are pins, but formerly thorns, or just little sticks, were used. When a cast is made and the counts determined, so many posts (comb-teeth) of the count-characters are counted off in the direction that player is moving his counter. The counter is then placed in the space (in case of a pin being used, it is stuck in the space) between that post and the next one in the direction he is moving his counter. Should the pin (counter) of an opposite player come to the same post space, the counter of the first player is taken up and that player must start all over again, having lost all the tallies he has previously made. In one way of playing the game, if a counter falls in one of the wide spaces its possessor also loses all the counts he has previously made and must start all over again. Sixty successive counts, the encircling of the entire board with the marker to the starting point (in one way of playing it, as least to one count past the starting point) constitute a game. The owner of these counts therefore wins.

Counts (numbers) to twenty, are used in playing the game. (The writer will add that the sounds used by the Utes are both slurred and nasalized. It should be added that many consonant sounds are between sounds of ours and are hard to indicate, as for example, "b" and "p," their sounds being neither of these but somewhere between them, depending in degree upon the person talking, as individual sounds and even words vary in pronunciation from person to person. The "nee" ending is often slurred or merely indicated by a continued breath, or a fading pronunciation. The vowels and vowel combinations here are pronounced somewhat as in English in the same positions, unless they are diacritically marked. A raised comma indicates a slight stop in the pronunciation, and letters or syllables inclosed in bracks are only slightly heard, often not heard at all. The writer obtained the numbers from different parties and will give them as given to him.)

1, suis, (as used by the store people) suez.
2, wain-nee, wain'ee, wine, (as used at the store) wain', or wane.
3, pine', bine', bi-ain-nee (all letters pronounced).
4, chu-wen-nee, stu-ain-nee.
5, mon-ey-gain-nee, manezen-nee, (as used by the store people) man-e-gan-nee.
6, na-vain, novain-nee, novain, novine.
7, novakai-win-nee, nah-wi-kay-win, (as used at the store) nah-vi-kay-win.
8, wauk'-chu- (w) a-ny'-nee, wauch-chu-wain-nee.
9, swa (t) -er-an-ser-any-nee, swaot-o-won-swain-nee.
10, tom-ser-a-ny, towam-ser-a-ny.
11, tom-ser-a-ny so-kwius chi-pe-kwot, tom-ser-any tsuk chi-pe-kwot, tom-swain-nee (shortened form).

12, tom-ser-a-ny wike chi-pe-kwot.
13, tom-ser-a-ny pike chi-pe-kwot.
14, tom-ser-a-ny whe-chuk chi-pe-kwot.
15, tom-ser-a-ny man-na-uke chi-pe-kwot.
16, tom-ser-a-ny nah-vike (or na-wike) chi-pe-kwot.
17, tom-ser-a-ny nah-vi-kok (or, nah-wi-kioke, or, nah-wi-kayoke, or, na-vi-kay' vok) chi-pe-kwot.
18, tom-ser-a-ny wash-chuke (or, wah' chuke) chi-pe-kwot.
19, tom-ser-a-ny sowar'm tsuke chi--pe-kwot.
20, wam-suen-nee, wam-su-way-nee[1].

[1]Articles have appeared on the hand games of the Utes at different times in the past, among which are: in Cullin, Stewart, Games of the Northern Indians, 24th Ann. Rep., Bur. Amer. Ethn., pp. 315; in Barber, Edwin A., Gaming Among the Utah Indians, American Naturalist, vol. 11, no. 6, pp. 351-352; and in Densmore, Frances, Northern Ute Music, Bull. 75, Bur. Amer. Ethn., pp. 174-187. The other games mentioned have never been brought to scientific notice before, so far as the writer can learn.

The games of these Indians are very similar to certain games played by other Indians of the west; the We-to-ob, Beaver Teeth, or Indian Dice Game and the Hal-th'-kob, two-stick, or "Chuck-luck" game of the Quileute Indians, the Pah-gay-say or Bowl game of the Bois Fort Ojibwa of Minnesota, Niaway, or Two-stick, Game of the Goshute Indians, and the moccasin games of the Apaches and Chippewas.

The writer's articles on Indian games are as follows:

Reagan, Albert B., Neahzhosh; or the Apache Pole Game, Proc. Ind. Acd. Sci., 1903, pp. 68-71: The Apache Stick Game (Setdilth), Proc. Ind. Acad. Sci., 1903, pp. 198-199 (republished in The Red Man, vol. 5, no. 2. pp. 54, 65, 76, Carlisle, Pa., 1912); The Apache Medicine Game, Proc. Ind. Acad. Sci., 1904, pp. 285-286; The Moccasin Game, Proc. Ind. Acad. Sci., 1904, pp. 289-292; Niaway, or the Two-Stick, Game (in "The Shoshoni-Goship Indians"), Trans. Kas. Acad. Sci., vol. 28, pp. 227-232, 1907 (republished in "The Deep Creek Reservation and its Indians," The Red Man, May-June, 1917, pp. 19-36; in "The Deep Creek Indians;" El Palacio, vol. 5, no. 2, pp. 30-42, July, 1917; and in "The Shoshoni-Goship Indians and the Deep Creek Region, Utah," Improvement Era, vol. 22, pp. 1040-1046, three illustrations, Salt Lake City, October-November, 1919); The Games of the Quieleute Indians, The Westerner, November Number, Seattle, 1907; Some Games of the Bois Fort Ojibwa, Am. Anthropologist, vol. 21, no. 3, pp. 264-278, July-Sept., 1919.

It should be added that the "board" of the Ute Stick Game here described was purchased from the Utes at Ouray by the writer for Dr. E. E. Hubert of Moscow, Idaho, from whom permission for the use of these data has been secured.

The Biology and Symptomology on Narcissus of Anguillulina Dipsaci Gerv. and v. Ben. in Relation to Quarantine Regulations[1]

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HISTORY

The leaf and stem nematode, *Anguillulina dipsaci* (Kuhn) Gerv. and v. Ben. known until recently as *Tylenchus dipsaci* Kuhn (7,20)[2] was first described and identified as a pest on Teasel (*Dipsacus fullonum*) in 1858. (11). Its disease symptoms on clover, oats, buckwheat, and rye have been known since 1825 when they were described by Bos (1). By 1890 it was known on thirty-four host plants among which were buttercup, shepherd's purse, spurry, geranium, clover, beans, teasel, cornflower, daisy, thistle, forget-me-not, carnation, plantain, polygonum, narcissus, galtonia, scilla, hyacinth, onion, oats, wheat, rye, buckwheat, potato, moss and narcissus. (1). Even at this early date it was known as a serious pest on rye, buckwheat, onion, hyacinth, galtonia, scilla, clover, spurry, oats, beans, carnation and potato.

By 1909 the number of known hosts had increased to 58 according to Marcinowski (12). Up to the present date it has been reported by Steiner on over 200 different hosts (21).

In the United States, this nematode was first reported by Bessey in Kansas in 1907 on rye (3). At present in continental United States it occurs on over 37 species of 23 genera of plants (21). Judged by the reports of findings on import materials, it is present on many still unreported host plants in foreign countries and probably in our own country.

The potential seriousness of *Anguillulina dipsaci,* due to the great number of hosts on which it occurs, cannot be accurately judged at this time because the ability of this nematode to transfer from one host to another has not been thoroughly investigated. The early extensive work of Ritzema Bos (1) in 1888 indicated that there was a ready transfer between hosts because a great many successful transfers were obtained. Recent investigations by Van Slogteren (18), Hodson (10), and Quanjer (15) indicate that some populations may be restricted to one host, others to only a few hosts, or others to many hosts. However, no experiment has included a test of one population of this nematode on all its known hosts. Steiner (22) has pointed out that a test should be made of each population before the importance of a particular *Anguillulina dipsaci* population on a particular host in a planting can be determined. Even the same population may contain monophagous, oligophagous, and polyphagous strains according to Wilson (23). Therefore, it appears that all populations of this nematode should be considered potentially polyphagous and may represent a real economic danger to a great many of our crops.

This nematode was first reported on narcissus in a field planting in 1887 by Ritzema Bos (1). The nematodes occurred in very small numbers causing no deformation and apparently

[1] Presented at the annual meeting of the Northwest Scientific Association, Dec. 27-28, 1933, Spokane, Wash.
[2] Numbers refer to bibliography.

gave no indications of becoming a serious pest to this crop. A rye crop on the same field the previous year was heavily infested with *Anguillulina dipsaci*. Bulb growers at that time reported that neither tulips, lilies nor narcissus previously had ever suffered from this nematode disease, so that presumably it was not prevalent or very serious.

Anguillulina dipsaci has been known as a pest on narcissus in Holland since 1910 (18). Investigation of it did not begin until 1917, hence it probably was not serious up to that time. Apparently its importance was recognized simultaneously in England, because Ramsbottom (17) began to develop the hot water treatment there in 1918. In western United States, it was first noted on narcissus in California in 1923 by Milbrath (13).

Life History

The life history of *Anguillulina dipsaci* is essentially the same in all hosts (9). It seems to be as follows: The female lays about 200 eggs, a single one at a time. Within each of these eggs, a small worm-like larva develops. This larva eventually breaks the shell and emerges as a worm about one-third the size of the adult. During its development the larva probably passes through four moults before becoming fully mature. The adult is approximately one-twentieth of an inch long. The entire development from egg to adult requires about four weeks. The number of generations varies according to climatic conditions.

All stages of the nematode may be found on the same plant at the same time. Quanjer found that it enters the plant through the stomata and lenticels (15). The lack of these openings in the roots of the plant as well as the absence of intercellular spaces between the cells may possibly be the reason that it is found only on the stems and leaves, hence the name "stem and leaf nematode". The eelworm travels between the loose cell structures as well as on the outside of the plant in the watery film produced by wet, damp, or dewy weather.

In the case of narcissus, the eelworm's ability to move on the surface of the plant is well illustrated by its presence in the folded buds and leaf scales. Inasmuch as the lesions in incipient infestations in the bulb scales are generally found in the scales produced by the current season's growth and not in older scales, it is likely that infestation takes place chiefly in the young leaves and spreads downward to the scale of each particular leaf. That this is true is further indicated by unsuccessful attempts to find incipient lesions in the older scales by the cutting and examining of many bulbs. During this sort of examination the spread from one scale to another through the basal plate of the bulb has been noticed.

Because the seasonal infestation seems generally to take place in the scales developed that year, a conclusion can be made as to the age of an infestation in the bulb from a determination of the age of the scales in which the lesions occur. By such an examination a diagnosis can be made as to the length of time a particular stock has been infested and consequently a decision reached whether the infestation is being carried by the stock or is only current infestation from the soil or from some other host.

That infestation takes place in a number of leaves simultaneously at certain times, possibly controlled by favorable weather conditions, is indicated by the fact that usually height zones of spikkels may be observed in an infested field, that is, the time of infestation is indicated by the height

of the spikkels above the ground. Two or three distinct height levels are often observed.

Moisture and temperature conditions which are favorable to the plant seem in turn favorable to the nematode. Long warm summers with moist conditions are most conducive to its development. On the contrary, plenty of moisture with cool weather or lack of moisture and warm weather do not result in rapid propagation. In Oregon and Washington it has been noted that the farther north the nematodes occur, the less the disease spreads and the less abundantly and rapidly disease symptoms appear in the fields. Also the symptoms of the infestation are less evident in the aerial part of the plant. Moreover, the disease develops first on the aerial part of the plant in the low places of the field. It also appears most abundantly and seriously at these points and may even be limited to such places in some fields so far as surface indications are concerned. However, this does not indicate its absence in the remainder of the field; there, later in the season, it may be found, though apparently absent earlier. Further, it has been determined that spikkels continue to appear throughout the growing season. This has been proved by careful inspection and roguing of infected plants every two weeks. Each time the plants were inspected, new diseased plants were found. In some cases no spikkels are formed in the leaves even in stock that has been infested for three years. This is especially true in varieties with large thick leaves, such as White Pearl and Grand Monarch. The same observation was true in one field of Golden Spur.

With reference to the control of the nematode, probably the most important phase of its life history is a resting or quiescent stage which the nematode assumes at any period in its life cycle under unfavorable conditions. The chief factor in causing the nematode to pass into the resting stage is lack of moisture. Drying of the soil, drying of scales or of entire bulbs will cause any of the stages of the nematode to become inactive. They will return to active life only when proper conditions prevail for their revival.

The various stages differ considerably in the length of the period they may remain dormant and still revive upon the application of moisture. The adults will withstand dryness only a few days; on the contrary, the oldest larvae or preadults may live for several years. In this preadult stage they have even been returned to active life after six years of dormancy. Ritzema Bos (1) and others have proved that as a rule, the longer the animals have dried. the longer it takes to revive them. For example, larvae dried two days require about one hour in water at 40° F.; those one month, ten hours; those two and one-half years, eight to twenty days. However this period for revival can be greatly shortened by using water at 60°-70° F. The optimum according to recent information kindly furnished by Courtney and Latta (5) seems to be 70°-80° F.

Temperature, even in the presence of moisture, is another important factor in producing a quiescent stage apparently somewhat similar to the resting stage produced by dryness. The lower the temperature, the slower the activity of the nematodes become; at a temperature near freezing they enter a dormant inactive stage. The larvae and eggs of *Anguillulina dipsaci* have survived in bulbs frozen to -2° F. when the bulbs were thawed out gradually. In bulbs thawed out quickly, the nematodes were all dead. Hence they may apparently survive in our coldest temperatures in winter for Bos

(1) and Chatin (4) both report that they can be frozen in ice and still revive if thawed out gradually. Likewise at the higher temperatures their activity is retarded and probably, if approached gradually, will enter a quiescent stage. Indeed, the relation of the nematode to temperature seems to follow rather closely that of plant proteins and enzymes. The development of the resting stage and its revival may be an enzymatic reaction. If this be true, then a temperature of 140°-200° F. would be required to kill this resting stage. This is strongly suggested by Hastings' results,[3] obtained in heating this species in the dried resting condition for 150 minutes at 138°-140° F. without apparent injury.

A third condition, which may force the nematode into a quiescent stage even at the favorable temperature of 70° F., is rot or decomposed material. The adults probably do not live long in this type of medium but the larvae survive much longer. Just how long has not yet been determined. However, if these rotted substances are allowed to dry, the nematode larvae may survive for years. Even if the larvae escape from the rotted bulb into water which is contaminated by the rotten bulbs, they will go into quiescent condition and remain there inactive for days. Placing them in fresh water will return them to active life.

The amount of light which a plant receives evidently has a considerable effect upon the activity of the nematode. Newton, Hastings, and Bosher (14) found that low temperatures and high light conditions favor the development of nematode symptoms in barley, while under high temperatures and low light, the nematode symptoms are inconspicuous or absent. Even at 70° F. nematodes in distilled water will become inactive in diffused light; on the other hand, if rays of light are centered upon them, the nematodes will gradually recover their very active movements.

Practically no investigations have been made on the effect of chemicals upon the various periods of development of this form, especially the resting stage due to dryness. Those chemical investigations which have been noted have been concerned only with killing the active nematodes. It seems very probable that chemicals may affect the activity of the nematodes in the same way as other unfavorable environmental factors. Likewise, the various stages of the life cycle may show a great difference in their resistance to chemicals. This is especially suggested by results of certain Russian investigations with other nematodes (24).

It is evident on the basis of our present knowledge that the preadult stage in the life cycle of *Anguillulina dipsaci* is the most resistant to unfavorable conditions, and consequently, is the stage in the life cycle which must be destroyed in any effort to eradicate this nematode. The failure to recognize this fact has rendered much of the experimental results of little value for determining methods for its eradication. As a result, the eelworm on narcissus in the Northwest has been brought under control but has not been eradicated.

That the hot water treatment of 110° F. for four hours under some conditions is not successful in killing the nematode on narcissus is well known. For example, eradication cannot be expected with one treatment of narcissus stock which has been excessively dried out. Moreover, the location of

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3 Letter from R. J. Hastings, Dom. Lab. Plant Path., Saanichton, B. C., Canada, to Dr. G. Steiner, U. S. Dept. Agr., Wash., D. C., Oct. 30, 1933.

the infestation in the bulb, or the length of the period the stock has been infested, will largely determine the results. If the lesions are near the surface of the bulb so that they can dry out during curing, or if bulbs are badly rotted, a carry-over generally results.

It has been repeatedly observed that the carryover is in the smaller bulbs or in large bulbs with lesions near the surface. Hence, the indications are that the difficulty is not so much due to lack of penetration of the heat as to lack of sufficient temperature. The temperature cannot, however, be raised much higher without serious injury to the bulbs. Therefore, more attention must be given to methods for avoiding or destroying these resistant stages if the nematode is to be eradicated from narcissus.

In consideration of the above facts care should be taken to conduct the sterilization in such a way that the conditions mentioned may be avoided. Some pertinent suggestions are as follows:

1. The bulbs should be immersed slowly in order to allow the escape of air and thus avoid, as far as possible, air pockets around or within the bulbs.

2. The water should be changed after each load if it has become colored because of rot in the bulbs. Active nematodes escaping into this water may become quiescent and, therefore, more resistant to heat and chemicals.

3. The bulbs should be presoaked at a temperature of 70° to 80° F. for a period of one or two hours, depending upon how long they have been dug. If this water has become contaminated by rot during the presoaking, it should be changed and not used for the treating.

4. The temperature of the water should be raised quickly to 110° F.

5. Vigorous circulation should be maintained at all times to keep a uniform temperature, to avoid hot or cool spots, and to remove the danger of the formation of a cooler layer of water around the individual bulbs as well as to prevent concentration of rot solutions around bulbs.

6. The refuse which collects in the bottom of the tank should be removed each day. Nematodes may become lodged in this refuse and not be subject to a killing temperature or may assume a quiescent condition.

7. Very thorough sanitation should be employed during the treating, that is, provision should be made for the destruction of refuse, disinfection of equipment, and sanitation of all tools, machinery, and other materials.

Much can be done previous to treatment to reduce the amount of nematode infestation as well as to place the stock into a better condition for successful treatment. Vigorous continuous roguing of a field as soon as infestation is discovered and destruction of all rogues by burning or burying with quicklime are suggested. This would eliminate both the heavily infested bulbs and the rotted bulbs from the stock to be treated. It would also reduce soil infestation. This would also cut down the possibility of spread and would eliminate infested bulbs which might be left in the field. After digging, the bulbs should be heavily culled; all rotted bulbs and refuse, particularly dried scales, should be discarded. The bulbs should not be cured over three weeks; a shorter period can be used if the bulbs are dug late. The past season has shown that, with this period of curing, the bulbs can be treated for four hours at 111.5° F. without injury. Dried scales and bulbs, as well as rogues, may perpetuate the infestation indefinitely in the field. These should, therefore, be carefully collected and destroyed.

Symptomology

A thorough knowledge of the various symptoms which are or may be indicative of nematode attack is fundamental to successful inspection and eradication of the nematode disease. Observation must be keen and careful at all times in order to learn how the disease manifests itself in different varieties under different seasonal, climatological, and soil conditions.

Up to the present time the field diagnosis has been based largely upon an examination of the aerial parts of the plants for spikkels. These are small swellings, often so inconspicuous that they are very difficult to recognize at any distance by the naked eye. They are to be detected by passing the leaf between two fingers. Spikkels are a prominent symptom of *Anguillulina dipsaci* attack but may be produced by other plant parasitic nematodes. In past years if spikkels were not found or, if found, and no nematodes were discovered in them, the plant was not considered as being infested by a nematode. Likewise brownish, dried-out spots with a longitudinal slit in them were noted many times, but if no swelling were present, it was not considered of nematode origin. In the two latter cases, two facts have been overlooked. Often only a single nematode may have caused the symptom. If the plants are quite well advanced in growth or if the leaves have been picked for any length of time, so that they have dried out or are beginning to wither, the nematode may have departed to another part of the plant. Under such conditions the whole plant must be examined thoroughly in order to find the nematode.

In other words, the inspection in the field heretofore has not advanced very far beyond the spikkel stage. Some infestations have been missed for two or three seasons because of failure to find the nematode in the spikkel or to recognize other symptoms, inasmuch as spikkels are not always produced. Moreover, the severity of infestation has been so reduced due to sterilization of the bulbs, and the symptoms have thereby been so submerged, that it is now necessary to examine the plants carefully for other conditions which may or may not be a manifestation of nematode infestation. The discovery of a sick plant, unless the cause is evident, necessitates an examination of the bulb and plant itself in order to determine whether the cause is due to a nematode. An excellent illustration of this is furnished by the recurrence this season of nematode attack in stock sterilized three years ago, and not treated since. Evidently the hot water reduced the number and vitality of the nematode in such a way that it did not produce spikkels on the leaves until the third year. As a result, the infestation was missed for two years.

In the task of field inspection, the inspector should look with suspicion upon any plant of abnormal appearance in the field. The plant may only show a partially stunted growth in both flower stalk and leaves or the flower stalk may be normal with shortened leaves. Again the plant may appear normal but show a slight twisting of the leaves in all the various degrees from that of a normal leaf to a typical sickle-shaped leaf. Certain leaves may present yellowish-white stripes, extending generally along the edges of the leaf—an indication of interference with the normal development of the leaf at its base. A few short, dried, or partially withered leaves may be present among the other normally growing leaves—an evidence that a "slab" or division of the bulb has for some reason failed in its development. Some or all of these symptoms may also be

a result of either the hot water treatment, mites, rots, mosaic, fly, leaf disease, poor planting or even other nematodes. In other words, when an abnormal plant is found, the cause of the condition of the plant must be determined.

In order to make the above diagnosis complete, the bulb itself must be examined for sympoms of attack. The action of nematodes on the bulb produces a typical lesion in the scale but even this symptom may be confused with other troubles. The nematodes work between the cells and gradually separate them, causing the disintegration of the middle lamella between the cells. The infested tissue turns a light yellow or brownish color. If viewed through a hand lens, the tissue looks web-like or mesh-like. This attacked tissue can be easily removed with the point of a knife. At this stage an abundance of nematodes will be present. The diseased portion will be found in the tissue between the scale sheaths, the disease exhibiting a tendency to extend laterally, but more rapidly toward the base of the bulb. It does not extend across to other scales. The scale sheath will remain intact and in many cases can be stripped off. If the infestation is incipient, the symptom will be in the scales produced during the current season as a result of leaf growth. Apparently within the bulb itself the spread from scale to scale takes place by the movement of the nematode to the base of the infected scale and then proceeding through the base to an adjoining scale. As the nematode pushes downward into the bulb, it leaves tissue susceptible to the invasion by other nematodes, fungi, bacteria and flies. It is not uncommon to find species of *Diplogaster, Cephalobus, Rhabditis,* etc., in the bulb tissue attacked by *Anguillulina dipsaci.* Indeed, some investigators have even suggested that where these common nematode associates of *Anguillulina dipsaci* are found in a bulb, it may be assumed with some certainty that *Anguillulina dipsaci* has been the initial cause of the trouble. As a result of these invasions of saprophytes or semiparasites, the tissue is rotted, turns black and extends to other scales, thus obscuring the typical symptoms of an infestation of *Anguillulina dipsaci.*

Anguillulina dipsaci is very intolerant of decomposing tissue and endeavors to move on as rapidly as the tissue rots. On the other hand, if it is not able to escape from the rot, it goes into a quiescent stage and eventually dies if the rot remains moist. If the rot dries out, it may remain dormant for an indefinite period and upon becoming moistened again will revive. Hence, in order to find active eelworms in old infested bulbs, the edges of the rot must be examined, generally at the bottom part. Likewise, if any eelworms are found in the older rotted part of the bulb, they will be stretched out and apparently dead. Some may be returned to life, however, if they are placed in fresh water for a few hours.

Upon discovery of a nematode, a definite determination of the species involved is necessary, since according to Steiner and Buhrer (19) this yellowish-brown lesion in the bulb scale and the spikkel in the leaf in narcissus are not entirely specific for *Anguillulina dipsaci.* All of the following nematode species may produce one of these symptoms: *Apbelenchoides fragariae,* the common strawberry nematode found in the East, Southeast, California, Oregon and Washington; *Aphelenchoides parietinus,* a rather common parasite on several plants, found on narcissus in Florida and on narcissus and bulbous iris in the West; *Aphelenchus avenae,* a general para-

site; *Aphelenchus hamatus* and *Cephalobus striatus*. After *Anguillulina dipsaci*, the strawberry nematode is the one most frequently found. Of all these nematodes on narcissus *Anguillulina dipsaci* is the most virulent.

Field Segregation of Nematode Infestations

The problem of separating infested stock from nematode-free stock in a planting is one of the most difficult phases of nematode eradication. It is almost impossible to set up definite rules regarding this matter and as a result the question must depend largely upon the analysis of a certain set of conditions. This analysis is predicated on a thorough familiarity with the pest, its reaction in the field, and its behavior under a certain combination of conditions, no two of which will be of the same importance in two successive cases.

The probable age of the infestation is of first importance. This may largely be determined by the location of the lesions in the bulb scales. Incipient attack may be indicated by the presence of only leaf symptoms in the spring or, later, by yellowish-brown areas in any of the four or five center scales. This condition would suggest soil infestation, spread from neighborhood bulbs, or introduction by tools, clothing, animals, birds, water, etc.

Two-year infestation would be probable if lesions are found in that part of the bulb developed last season; namely, in approximately the fourth to the eighth or ninth scale counting from the center. The lesions may extend quite deeply into the bulb, often reaching the base. The nematodes would be found only at the lower edge of this lesion, or possibly through the base to the current season's scales. They would be advancing from the base of the bulb.

Three or more years' infestation would be shown by the presence of nematodes in the outer scales of the relatively large bulbs extending often into the dried-up scales. Each year the contents of nearly the same number of scales as were produced on the inside of the bulb are absorbed for growth and become merely dried scales on the outside of the bulb. For this reason this stage is often not apparent unless an examination is made for the nematode in the dried-up bulb scales. Here it might be found in the typical coiled resting stage.

Bulbs showing two or more years' infestation indicate that the particular variety has been infested two or three years. The nematodes may be present in any part of the stock; consequently, the whole variety should be treated, no matter how many blocks of them are being grown. There may be apparent exceptions to this rule. For example, two cases have been known where the owners sent a portion of a variety to a warehouse to be sold. All the bulbs were not sold and some were returned. These were planted in a block of the same variety. One center of old nematode infestation was found in this block. No nematode had been found in this planting before and no other infested spots were discovered. The evidence was fairly conclusive that some of the bulbs returned to the grower were not from his original stock.

However, in incipient infestations there is more possibility of segregation in a variety if certain facts can be determined. Natural spread from another diseased block, all other factors being favorable, may allow for segregation. On the other hand, any bulbs planted on infested soil must be considered as potentially diseased. If the facts show that only part of the plot was probably previously infested, the uninfested part may be considered

safe, provided no other circumstances complicate the situation.

It is important to discover the probable distribution of eelworms in a current season's infestation. However, this is very difficult to determine, because the symptoms keep appearing throughout the season, as the various sites in the field acquire a favorable environment for the development of the nematode. Only by careful inspection throughout the growing season can a fair determination of distribution be made. Fall storage inspection of the bulbs may give additional information. The combination of these two by actual field test indicates that under average conditions field inspection may reveal only ten per cent of the actual infestation in the bulbs. On the other hand, light attacks have been found in the field inspection whereas no nematode could be found by examining the bulbs in storage and the reverse has also been reported. Therefore, a combination of these two inspections is fundamental; neither one alone is fully efficient from the eradication viewpoint.

The length of time the bulbs have been planted may prove a factor in distribution. For example, if infestation has developed after the bulbs have been planted and if they have not been dug for two, three or more years, the distribution may not be general. On the contrary, if the bulbs have been dug every year, a general distribution of the infestation throughout the field almost certainly results, because the bulbs from different parts of the block become mixed while in storage and during sorting.

Topography is especially important. This of course determines the direction of flow of both the surface and subsurface water. It is a well-known fact that eelworms move or are carried in water. In this way, floods, heavy rains, or subsoil or irrigation water may carry them for long distances. Cases of spread for 500 feet by such means have been observed. A nematode will travel considerable distance of its own accord, even against the general water drainage, before it finds its particular host plant Furthermore distribution by irrigation water, heavy rains, or floods may, if occuring during the latter part of the growing season, distribute the infestation after the plants are well advanced in their development. Consequently, no surface indication of infestation may be found that season. The distance and amount of this type of spread will also vary considerably, depending upon whether the soil is light, sandy or quite heavy.

In addition to the above, the past history of the bulbs themselves may indicate probable general infestation of the stock. For example, if the bulbs originate in a known infested area, all of them must necessarily be suspected of carrying nematodes. Further, if a variety consists of mixed lots from several sources, some of which have been infested, it may be necessary to treat the entire lot. This is especially true if the bulbs have been dug and sorted in such a way that the infested stock has been scattered throughout the variety. The character or type of treatment of the bulbs must also be considered. If this has been done by an unproved method, with ineffective equipment, or in an unsatisfactory manner, the bulbs should be considered as potentially infested.

The type or character of the past inspection of the bulbs is quite important in judging whether it is probable that all the stock or only parts of it carry the nematode. If an inspector is not particularly familiar with the nematode, does not inspect thoroughly, inspects too early, or omits the fall inspection, his decision regarding the

presence or absence of *Anguillulina dipsaci* in the bulbs cannot be relied upon.

Even the origin of the stock, whether domestic, foreign, or greenhouse, may justify precautionary measures. Some states are more badly infested than others. I do not believe that the treatment of greenhouse infested bulbs is yet successful. If infestation is found in part of a block, and it is learned that only a dormant bulb inspection has heretofore been made of the stock concerned, assumption that the entire block is infested may be considered justified.

Likewise, some information regarding the past history of the field itself should be obtained. If the field has ever had narcissus on it before, and if current season infestation appears, it is quite likely that the ground was infested by this former crop. If nematode infestation has occurred previously in the field, it is necessary to know the rotation of crops and the type of farming employed. It is wise to determine the sanitary measures undertaken as well as the length of time the field has been infested. These facts can give information as to the probability of a general infestation as well as the possibility of any crops having harbored the pest during the rotation period, and having served as a means for its temporary survival until the replanting of the preferred host.

In summarizing the question of field separation of infested from non-infested bulbs of the same variety, the conclusion must be that only in cases of infestation originating that particular season can this be accomplished. And then only, if all the facts in the case indicate that the entire block of stock is probably not infested. In all cases where there is any suggestion that eelworms may exist in an entire lot of bulbs, the whole variety or block must be considered infested. Lack of realization of this one principle has been more responsible for the general distribution of *Anguillulina dipsaci* on narcissus in the North Pacific Coast states than any other factor. Because all the facts in a particular case very seldom can be determined, certain assumptions must be made and sterilization required accordingly. Action must depend upon the principles mentioned above. These principles must be based on facts proven or suggested by experience.

Fundamentally, the success of an eradication program depends upon the inspector's ability, his willingness, and his determination to obtain the facts, as well as his interpretation and application of these facts. There is still much to be accomplished in the development of trained personnel. As indicated above, an accurate technical knowledge in a highly specialized field coupled with a considerable amount of experience is necessary.

Program for the Elimination of a Nematode Infestation

With careful adherence to a definite program based on the known information resulting from research investigations as well as from field observations, eradication or, at least, very complete control of *Anguillulina dipsaci* can be obtained. Some authorities have suggested that careful cultivation and due consideration to the crops used will eliminate the nematode from soil within four years. Other authorities have stated that land once infested can never be freed from nematode. This point is not settled as yet; only further observation and experience can answer this question. Successful elimination of the nematode depends partly upon whether the nematode on narcissus in a particular

planting is definitely restricted to this plant as a biological race or will attack other plants or at least survive on them (16). There is some information for supporting either one of these positions but, as indicated in the first part of this paper, the preponderance of evidence at present refutes the idea that *Anguillulina dipsaci* on narcissus is a specialized race or strain which will not transfer to other hosts. Therefore, it seems desirable to adopt as safe a horticultural practice as possible. Under such circumstances, it would appear that the following procedure offers the best chance of success. The ultimate result, then, will be determined by the thoroughness with which the procedure is carried out.

1. The planting should be vigorously rogued during the growing season in order to eliminate bulbs attacked by nematodes, rots, mosaic, etc. This means the destruction of all visibly infested as well as all weak plants, in order to develop a healthy, vigorous stock. I doubt whether disinfecting the ground and leaving the attacked bulbs in place is advisable because a chemical has not yet been found which will completely kill the nematode in the soil and bulb.

2. The field should be isolated and all tools, machinery, or any equipment which may carry soil particles should be disinfected before being taken from the field. A ten per cent solution of formalin or two per cent solution of carbolic acid is suggested for this purpose on the basis of the results obtained by Newton, Hastings, and Bosher (14). This should be used while the soil is still moist. If the soil is allowed to dry, the nematode may go into a resting stage. Inasmuch as no investigation of the effect of chemicals upon the resting stage of the nematode has been made, the strength of chemical which will be effective cannot be recommended. Kerosene has been generally used but present indications are that it is not satisfactory as a soil disinfectant and should not be employed for this purpose. In the case of some other nematodes, it has been determined in Russia that the older larvae are very much more resistant to chemicals than the younger ones (24). It is very probable also that the resting larval stage of *Anguillulina dipsaci* may be much more resistant to chemicals than the active stages.

3. Infested stock should be sorted in the field where grown, so that the bulbs may be hauled directly to the treating tank. This will aid in keeping the warehouse free from infested material.

4. A regular hot water treating program should be inaugurated so that all planting stock will receive the treatment every second year or at least every third year. Heavily infested stock should be treated two years in succession.

5. In the fall, all narcissus bulbs or refuse of the same should be removed from the field and destroyed. All rogues should be dug and destroyed the following spring.

6. Clean cultivation should be practiced the season following the infestation. If necessary, a crop should be planted not known as a host, a crop which can be cultivated and kept free from weeds. Corn, lettuce, asparagus or tomatoes are suggested. The elimination of the common weeds such as chickweed, plantain, dandelions, tumble weed, milkweed and lamb's quarter—in fact, most of the common weeds that occur in narcissus fields—is necessary. All are known to be hosts of this nematode and may therefore act as bridging hosts (16) during the rotation.

7. For the rest of the period of ro-

tation, only annual, quick-growing crops should be planted. Over-winter, biennial, or perennial crops may be the means of perpetuating the pest. Such crops as clover, alfalfa, fall grains, strawberries, etc. should not be used in the rotation. Beans, peas, cabbage, lettuce, potatoes, carrots, and spinach may be planted. These latter crops are all reported as hosts of the nematode (21), but there is a minimum amount of danger if they are used in the latter part of the rotation following good summer fallow. None of these should be used more than once, however, during the rotation as otherwise the nematode may become adapted to one of the intervening crops. Potatoes, if used, should be planted during only the last part of the rotation, since *Anguillulina dipsaci* in some countries is a serious pest to this crop (1, 15) As far as possible crops which are known to be damaged by this nematode should of course be avoided.

8. If bulbous crops other than narcissus must be planted, they should be used during the latter part of the rotation. It seems best to avoid the use of tulips and bulbous iris. Two actual field examples of apparent transfer to these two hosts have been observed in the Northwest. Further, *Anguillulina dipsaci* is reported by Drayton (6) to be as serious a pest of the tulip in some foreign countries as it is to the narcissus.

9. At least a four year rotation should be followed on infested ground and a two or three year rotation even on uninfested soil.

10. Narcissus bulbs obtained from outside sources should be planted in a separate plot from the grower's own supply and kept separate for two or three years before adding them to the planting stock. During this time the new stock should be hot-water treated at least twice. In this way, infestation of clean stock and clean ground may be avoided.

Conclusion

The biological facts concerning *Anguillulina dipsaci* have been summarized and their practical application as a basis for the eradication program which is being developed has been indicated. A few observations based on field experience have been recorded. Attention has been called to certain biological phases of *Anguillulina dipsaci* as yet only partially investigated. Although an extensive amount of literature has been examined, the bibliography referred to is only a representative selection and does not include all articles referring to a particular point. Some of the suggestions offered are only tentative, resulting from the lack of complete investigational work, but are presented with the thought that improved methods are needed to protect a rapidly developing industry from this serious, introduced pest.

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Dr. W. J. Kerr, chancellor of Oregon's system of higher education, announced that Herbert A. Bork, controller of the University of Wisconsin since 1927, will assume a similar position with the Oregon institution March 1.

Dr. J. A. Kostalek, dean of the College of Letters and Science, University of Idaho, has been granted sabbatical leave. He plans to spend most of his time in study at various educational institutions. Dean T. S. Kerr of the Junior College, will act as Dean of the College of Letters and Science in Dr. Kostalek's absence.

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Vol. VIII No. 2

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A scientific journal published quarterly by the Northwest Scientific Association and devoted to the dissemination and promulgation of scientific effort in the Pacific Northwest

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NORTHWEST SCIENCE

Entered as second class matter April 5, 1927, at the Post-Office at Cheney, Washington. Office of Publication, Cheney, Wash.

Published quarterly at a subscription price of $1.00 per year, which includes the membership dues of the Association. Non members $1.00 per year. Vols. I (1927), II (1928), III (1929), IV (1930), V (1931), VI (1932), VII (1933), complete, each $1.25.

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NORTHWEST SCIENCE

Vol. VIII JUNE, 1934 No. 2

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EDITORIAL

It was with deep sorrow that the members of the Northwest Scientific Association learned of the death on March 8, 1934, of Francis Garner Miller, Dean of the School of Forestry at the University of Idaho since 1917. Dean Miller was one of the staunchest suppoorters of our organization and gave much of his time during the last months of his life to the activities of the Board of Trustees. His efforts in completing a survey of the research problems of the Inland Empire are especially noteworthy and his report of the work is published in this issue.

That we have lost a friend, a colleague and a wise counsellor has been our deep realization. Our consolation lies in the thought that his good work will continue to be felt many years hence. A man so sincere in his profession and so devoted as a Christian could not fail to leave behind a lasting impression upon those with whom he came in contact.

Dean Miller was born at Lanark, Illinois, June 2, 1866, the son of Isaiah and Isabel Jane Miller. In 1893 he was graduated from the Iowa State Normal School, and served as superintendent of public schools in Iowa from 1893 to 1899. He was graduated from the University of Iowa in 1900. He received the Bachelor of Science degree from Iowa State College in 1901, and the degree of Master of Forestry from Yale University in 1903. He married Evelyn Depew Miller September 15, 1906, in Kansas City, Mo. From 1903 to 1907 he served as professor of forestry at the University of Nebraska, during which time he was also associated with the Forest Service of the United States Department of Agriculture.

In 1907 he organized the College of Forestry of the University of Washington at Seattle and retained the deanship until 1912 when he entered a business enterprise. He was induced to return to forestry in 1915 when he became head of the forestry department of the State College of Washington, Pullman, where he remained until 1917. In the fall of that year (1917) he became dean of the School of Forestry, University of Idaho, when the department was organized as a separate division of the University.

Dean Miller was very prominent in professional forestry circles and belonged to many forestry and scientific associations. He was a fellow in the American Association for the Advancement of Science; a member of Sigma Xi, national science group; Xi Sigma Pi, honorary forestry, and Alpha Zeta, honorary agriculture. He was also a member of Delta Chi, social fraternity, and of the American Association of University Professors. He was active in the Society of American Foresters and in the American Forestry Association. As chairman of the Board of Trustees of the Northwest Scientific Association he had recently completed a most thorough sur-

vey of the research needs of the Inland Empire. He served continuously on the Idaho State Cooperative Board of Forestry since its inception, and has been a prominent contributor to various technical journals on forestry topics.

Dean Miller was active until a week previous to his death, having been occupied especially in bringing to a successful consummation certain steps leading to the consolidation and administration of the new school forest. His success may be attributed in no small measure to a capacity for taking infinite pains that so characterized his work, and to his uncommon insight into his own problems and those of his students and associates.

An impressive memorial service was held in the University Auditorium, Friday afternoon, March 9, at which very fittingly, the members of his senior class in forest management were the active pallbearers, and the deans of the other divisions of the University were the honorary pallbearers.

Of interest to forest investigators is the bill, introducted by Compton I. White of Idaho, as passed by Congress in April, 1934, which permits the inclusion of approximately 64,000 acres of timber land in the National Forest area near Moscow, Idaho. This is a preliminary step in the eventual possession by the University of Idaho School of Forestry as an Experimental Forest. In March, 1934, an additional 160 acres of timber land was purchased by the University in order to acquire the camp site of the State-operated C.C.C. camp S-260 which was established in the fall of 1933. Operating through the winter this camp constructed roads and trails, telephone lines, firebreaks, and set up on Bald Peak, a modern lookout tower. Through the cooperation of members of the School of Forestry faculty, experimental plots, plantings and numerous other cultural projects are being carried out on the Moscow Mountain area. This Experimental Forest will eventually constitute one of the largest and most useful outdoor laboratories for forest instruction and forest research and will be within an hour's drive from the University.

Hydrocyanic acid, deadliest of all simple chemical compounds, is formed in the caps of two species of mushroom, it has been discovered by M. Mirande. The poison was found in the gills of a small mushroom belonging to the genus Marasmius; it is extractable in cold water from both fresh and dried material, though neither the spores nor the underground root-like threads of the mushroom contain it. The second hydorcyanic-acid yeilding mushroom belongs to the genus Clitocype; the poisonous night-shining American species known as the "jack-o'-lantern mushroom" is also a member of this group. This mushroom, unlike the Marasmius species, gives up its poison only when heated.—*Science*.

Accomplishments of the Civilian Conservation Corps in Blister Rust Control[1]

By Stephen N. Wyckoff
Division of Blister Rust Control, Spokane, Wash.

To evaluate the accomplishments of the Civilian Conservation Corps in blister rust control work is a difficult problem. The Civilian Conservation Corps was established for a dual purpose; to provide employment for large numbers of young men and to perform needed work in our forests. These two purposes are so intimately related that to measure the results in one field without taking the other into account necessarily gives a misleading picture. We shall obviously never succeed in placing a financial valuation upon the social profits derived from this great undertaking. Presumably a financial basis of valuation should be possible for the work accomplished, but each type of benefit must be evaluated in relation to the other. The problem of fusing these two types of benefits into one must necessarily be left to someone with the temerity and knowledge to undertake such a synthesis. My own discussion will properly limit itself to the financial and other direct benefits of the Civilian Conservation Corps in one of its lines of activity.

Thirty-four Civilian Conservation Corps camps in northern Idaho were assigned to blister rust control work during the summer of 1933. Six of these camps were on the Coeur d'Alene National Forest, 14 were on the St. Joe National Forest or in its immediate vicinity, and 14 were in the Clearwater forest area. These camps undertook blister rust control work as soon as they were established in the latter part of June and continued at this activity until about the last of September. During this period approximately 158,000 man-days were spent on blister rust control. As a result about 166,000 acres of the white pine area were given initial treatment for the eradication of Ribes, and 5,000 acres which had been previously worked over for the first time were given second treatment.

It is, of course, impossible to compute a definite cost per acre for this work. No figures are available that would enable us to make such a computation. It is possible, however, to determine the value of blister rust control work performed in northern Idaho by the Civilian Conservation Corps in terms of the cost of such work performed in the same general localities in past years. The application of past cost figures, by eradication types and by localities, enables us to place a valuation of approximately $500,000 on this work. By this statement I mean that if the Civilian Conservation Corps had not been available for this work, an allotment of $500,000 to actual control operations would have been necessary to achieve the same results. This is, I believe, the only basis upon which we can sensibly evaluate the blister rust control work performed by the Civilian Conservation Corps.

I do not suppose that anyone expected the work of the Civilian Conesrvation Corps to be as efficient as that performed by other types of labor. It would have been nothing short of miraculous had this been the case. These men were on the average much younger than those customarily em-

*Presented at the annual meeting of the Northwest Scientific Association, Spokane, Washington, Dec. 27-28, 1933.

ployed for such work. In a great majority of cases they were entirely unaccustomed to work of this type, and found themselves under living conditions and in an environment totally different from anything they had previously experienced. Many of them had never before performed manual labor. It is also probable that owing to their previous situations, some of them arrived at the scene of action in a frame of mind not conducive to work. Under such circumstances, the accomplishment secured is one of the greatest justifications for the project.

It is interesting to compare, on a detailed basis, the work of the Civilian Conservation Corps with that performed in the blister rust control operation of northern Idaho in the previous year. In 1932 approximately 120,000 acres of land were cleared of Ribes in the northern Idaho white pine type. This work was performed by older and more experienced men, most of whom were thoroughly familiar with work and living conditions in the woods. Furthermore, they were specially selected from a large group of applicants. We should naturally expect the work of such men to be more efficient. The brief analysis that I wish to present here is not to be considered as a criticism of the Civilian Conservation Corps. Rather, it has been made to determine if further work of a similar nature might be strengthened and made more effective.

For purposes of the present discussion, it is necessary to understand quite definitely what we mean by the word efficiency. In blister rust control work we can think of two kinds of efficiency, protection efficiency and cost efficiency. Protection efficiency involves the eradication of Ribes from the white pine bearing lands to such an extent as to protect the pine from white pine blister rust. This sort of efficiency is guarded by definite standards set up by the Division of Blister Rust Control and by the checking of worked areas to determine if the standards have been met. Cost efficiency involves the performance of the work at the lowest possible cost. It is readily understandable that the protection efficiency of a crew in working a specific area might be below the standard, thereby involving second working. This would secure the requisite protection efficiency but would, of course, materially increase the cost per acre and thereby lower the cost efficiency. The blister rust control work performed by the Civilian Conservation Corps met the standards of protection efficiency. In so doing, however, the cost efficiency was decreased, because of the necessity for reworking parts of the area.

As has been stated before, no actual cost figures are available for the work of the Civilian Conservation Corps. It is therefore impossible to determine cost efficiency on the basis of cost per acre of the work. It is possible, however, to measure this type of efficiency in terms of man-days per acre spent in performing the work.

The following brief tabulation gives a comparison of the man'days per acre on different eradication types, on the basis of equal numbers of Ribes per acre, for the northern Idaho blister rust control operations in 1932 and the work of the Civilian Conservation Corps in 1933. You will observe that there is a constant but hardly uniform increase in the number of man-days per acre spent by the Civilian Conservation Corps over those of the 1932 operations. This is, I believe, merely an expression of the youth and inexperience of the men doing the work. I imagine that at this point someone wishes to ask me just what I mean by a Civilian Conservation Corps manday. As here used, this term does not

mean the actual number of calendar days which the men concerned spent on this work. For purposes of comparison, it has been placed on a basis more nearly comparable with the results of 1932 operation. As here used, the term man-day means the total number of actual working hours spent on the job divided by eight. This system, of course, does not count against the work time devoted to other activities, or the time of men who were held in camp for a variety of reasons. It is, however, a reasonably comparable figure used in relation to the man-day figures available for the 1932 work.

MAN-DAYS PER ACRE, IN 1932 AND 1933, ON AREAS OF DIFFERENT ERADICATION TYPES, WITH EQUAL NUMBERS OF RIBES PER ACRE FOR EACH TYPE.

Eradication Type	Ribes Per Acre	Man-Days Per Acre 1932 Operation	Man-Days Per Acre 1933 C.C.C. Operation
Open Reproduction	472	1.22	1.52
Dense Reproduction	120	.50	.94
Open Pole ..	125	.40	.76
Dense Pole ..	57	.23	.37
Open Mature	125	.44	.57
Stream	396	1.07	2.29
Average ..	229	.68	1.00

In this connection, it is interesting to note the figures resulting from what is known as the effectiveness ratio. On the St. Joe blister rust control operation 14 Civilian Conservation Corps camps were engaged in blister rust control work. The average enrolled strength in each of these camps for the entire season was 185 men. The average number of men available to the camp superintendent for work was 122. From these figures there is derived what we term the effectiveness ratio, expressed as the percentage of enrolled men available for field work. In this particular case it is seen that for the average of the entire season 66 percent of the enrolled men were daily available for work. The figures for each camp for the season which are involved in this average of 66 percent range from 57 percent to 71 percent. In general, it can be said that this figure very closely reflected the attitude of the officers in charge of the camp, their willingness to cooperate with the camp superintendent, and their interest in the field work.

It is obvious that if the Civilian Conservation Corps were to be again organized, with the experience in its direction which is now available, a more highly capable system could be set up. This is, I believe, plain to anyone who considers the magnitude of the undertaking and the speed with which it was put into effect. Recent reports in the press indicate that the Civilian Conservation Corps may be continued in existence for a considerable period of time. This will mean the location of new camps and the abandonment of old ones as various work projects are completed and in accordance with seasonal conditions in the regions concerned. A careful analysis of the organization methods thus far employed might well indicate points at which they could be strengthened, the working program made more effective, and greater good brought to the large numbers of enrolled men. To the writer it appears that the present period, following the completion of large-scale Civilian Conservation Corps operations in this region, should be devoted to such an analysis. It should be entirely free from the spirit of criticism and wholly for the purpose of making the continuation of this program more effective. The following points are reasonably obvious to anyone engaged in the technical supervision of the Civilian Conservation Corps work. Many other would doubtless appear upon careful analysis.

(1) The period of camp construction should be materially shortened. Past experience in this activity should make this possible.

(2) The officers in command of camps should be fully imbued with the point of view that one of the primary purposes of the program is served by making available to the camp superintendents the greatest possible number of men for the work projects.

(3) The forest agencies concerned with the technical supervision of Civilian Conservation Corps work should exhaust all efforts to secure superintendents and foremen possessing not only the requisite technical knowledge but also the point of view necessary for supervision of these young men. Technical supervisors of broad sympathy, a high degree of tact, and natural characteristics of leadership are vitally necessary. By securing the loyalty of the enrolled personnel, such men can materially aid in social rehabilitation as well as in the progress of the working projects.

(4) The enrolled personnel of the camps should, so far as humanly possible, be engaged upon forestry work. There should be no sympathy but swift punishment for the malingerer. This conception is based upon the indubitable point of the value of work as a rehabilitating agent. The person who gets something for nothing is bound to suffer deterioration. The most valuable lesson which could be taught to these young men would be that for value received they must deliver an equivalent in service. For their future good it should be apparent to them that the work upon which they are engaged is of a beneficial and constructive nature. To me it is doubtful if the young man who spent the majority of his Civilian Conservation Corps enrollment in the construction of temporary ball parks and dancing pavilions will in future years look back upon his experience with the same degree of pride as those who worked at blister rust control, built roads, erected lookout towers, or performed other constructive tasks to which they were assigned.

Research Needs of the Immediate Future in the Inland Empire[1]

By F. G. Miller

Introductory

At its annual meeting in December, 1932, the Northwest Scientific Association inaugurated a movement to encourage research in the Inland Empire, the region which the Association represents. The amended constitution providing for an enlarged Board of Trustees charges this Board with the responsibility of formulating plans for raising an endowment fund or of providing funds in other ways with which to promote research for the development of the region.

It is pointed out to the Board that, although the Inland Empire has unrivaled potential resources, it is doubtful whether as much as $100,000 in the way of private funds are available for the development and orderly use of these resources. A considerable amount of state and federal money is available for this purpose, but the amount is wholly inadequate to meet the needs of the situation. Moreover there are many qualified investigators besides those in state and federal employ with little or no funds with which to carry on fundamental research. Some of the latter in their zeal for public service are engaged with highly important projects at personal expense.

As the basis for the inauguration of a campaign in an effort to create a research foundation from private donations the Board of Trustees at a meeting in Spokane last May decided to make a survey of the status of research in the Inland Empire not so much with reference to research done in the past or now under way but with special reference to the research needs of the immediate future. It fell to the lot of the writer to conduct this survey.

Accordingly a questionnaire was formulated and this together with a letter explaining purpose of the survey was sent to those engaged in research in the various educational institutions as well as to those conducting independent research in as far as the names and addresses of the latter were known. No doubt, however, many now doing notable work were missed.

The response to the questionnaire has been very satisfactory and gives a good concensus of opinion as to the more important fields of investigation work most in need for the immediate future. The projects proposed, classified alphabetically by the fields of work into which they divide themselves appear as an appendix to this report. The projects are numbered serially and the numbers in parenthesis used in this report refer to the projects as numbered in the appendix.

A Survey of Natural Resources

Since the economic future of the Inland Empire is so intimately dependent upon its natural resources, it would seem that a survey of these resources should be completed as early as possible. The fact that California started such a survey many years ago and has continued this work in a prolonged and systematic study is said to have given the state a decided advantage in acquiring federal money for irrigation and other developments. The Inland Empire states have been slow to see

*The Inland Empire is the region composed of western Montana, northern Idaho, eastern Washington and eastern Oregon.

the advantages of a survey of this kind. Washington is just now undertaking a study of her natural resources with $80,000 appropriated by the state legislature, this to be matched by an equal amount of federal money. As the raw materials are the basis of industry a knowledge of possibilities in this regard would encourage the immigration of industrial enterprises.

Land Classification

Soil surveys and land classification are suggested by several projects (2), (9), (12), (52), (85), (86) and (102) and such studies are a logical beginning in a survey of natural resources. The lands should be scientifically classified as to their adaptability for agriculture, forestry, grazing, recreation, water power or other purpose and each class put to its best use. Considerable progress has already been made in soil surveys by the states in cooperation with the federal government but owing to lack of funds the work goes forward slowly, as is pointed out in comments on projects (52), (85) and (86). "These surveys serve as an invaluable guide to prospective land users," says one correspondent. Another adds, "Many maladjustments of settlers on land could be prevented, as investors and others would know the truth concerning the use of our land instead of guessing it." A lack of land classification has precipitated the marginal land problem for which the federal government is now seeking a solution, some 35,000,000 acres now in agricultural use being involved.

A form of land use which has received little or no attention in the past is that of use by wild life, (95). "In Europe," a comment by the correspondent proposing this project says, "this phase of forest management frequently overshadows management for strictly timber culture. Until just recently American foresters have paid little or no attention to this form of land utilization, which, if considered from a purely economic standpoint has already in some instances demonstrated that revenues derived from the most elementary form of game management on specific forest areas have exceeded revenues possible under strictly timber culture. There is reason to believe that wild life studies have reasonable prospects of being endowed by some of our sportsmen."

In this same connection the economic possibilities of recreational resources, (51), must not be overlooked. The Inland Empire with its unsurpassed scenic attractions, its lakes and streams, and abundant wild life has recreational possibilities of high potential value. Recreation will one day come to be a leading commercial resource. In Michigan it is said that recreation is now the leading single industry of the state.

Mineral Resources

The very systematic survey of mineral resources conducted in Idaho over a period of years by the Idaho Bureau of Mines and Geology, and by similar agencies in Montana and Washington has been of inestimable value to the states concerned, more especially to the mining industry. Research in mining and metallurgy conducted in the Inland Empire has attracted international attention and forecasts future achievements in this field if the work is properly financed.

Forest Resources

The survey of forest resources now under way in the Inland Empire by the federal government, which now seems fairly assured of sufficient funds to complete it, will supply complete and reliable data on forest possibilities.

Industrial Survey

One project (84) calls for an industrial survey with maps of all towns

supporting industrial establishments. This would make a valuable study.

Conservation of National Resources

Soil

Of even greater importance than to know what our natural resources are is their intelligent use and conservation. A movement in point now being launched on a large scale with promise of adequate financial backing by the federal government is the control of soil erosion. While the program is nation wide, the Inland Empire is sharing generously in the appropriations, some $300,000 having been allotted to support a three-year experiment project in the Palouse farming belt of Washington and Idaho, (6), (7) and (8)). The toll on soil fertility from year to year in this belt is astounding and this new phase of conservation is most timely.

Forest Conservation

Two very significant movements have developed within the past year each having for its primary purpose the conservation of forest resources. The first is the organization of the Civilian Conservation Corps which is rendering highly important service in blister rust control, the reduction of losses from forest fires and the renewal of the forest by planting. The second is the adoption of The Code of Fair Competition for Lumber and Timber Products Industries which pledges private owners to leave their lands in a condition of continuous timber production. Under the impetus of these measures the perpetuation of the forest industries seems assured.

Conservation of Minerals

In practically every field of the mineral industry measures of recovery and utilization are constantly being developed for the conservation of the mineral wealth. "To prolong the life of our mineral deposits," a quotation from John Hays Hammond runs, "every effort should be made to reduce the cost of mining operations and at the same time to increase the efficiency of metallurgical methods in order to make low-grade ores available for profitable extraction. Today we are mining ores of gold, silver, lead, zinc, copper and other metals that ten years ago would have been unmined and have been irretrievably lost because of prohibitive costs. And recent research work has also found new uses for these metals, thereby increasing their market price, which in turn makes possible the working of low-grade ores." Fundamental research of far reaching importance to the mineral industry of the region is proposed in the list of projects under mining.

Considerable space is given to a discussion of soils, forests, and minerals. These are basic resources and their intelligent use is essential to a comprehensive program of research such as is indicated by the list of projects herein reported. These projects classify themselves into twenty different fields. Space will not permit a discussion even of each field, much less of each project. Suffice it to say that the list, even if very incomplete, is an impressive one and the research it suggests is essential to the economic and social progress of the region. The national blow recently struck at research and the recent curtailment of financial support for the American educational system make it imperative for all organizations such as ours to go to battle for the objectives for which they stand.

Some Suggestions for Increasing Funds for Research

Much research suggested will doubtless receive more or less support from federal and state funds. This is especially true of agriculture and to a lesser degree of mining, geology, engineering, forestry, home economics and possibly other fields, though every

field must have additional finances to carry on at all adequately.

Scholarships and Fellowships

Funds for research will probably come most readily to those projects giving promise of industrial development of the region. One of the most common forms of donations is for the establishment of research scholarships and fellowships by industry. Industrial and Engineering Chemistry for May 20, 1932, reports a formidable list of research scholarships and fellowships. More than one hundred industrial concerns and industrial associations share in their support. They are maintained at various educational institutions and at the laboratories of industrial corporations, some of them in the Inland Empire. With the proper approach doubtless the industries would increase their funds for fellowships for this region. An essential to qualify for such a support is to be able to offer something in the way of research that the industry wants. Some fellowships are now maintained at the educational institutions by local citizens or industries, and the institutions themselves support a number out of state funds. These examples may suggest other local possibilities.

Endowments

The president of a large state university, some years ago, advocated in a radio talk, the idea of a very large endowment for the support of the institutions on the grounds that the time would come when the state could no longer support the university at its normally high level by taxation alone. The press of the state received the suggestion rather coolly. Two years later in another radio address the president renewed the idea and this time the press was sympathetic with the suggestion. Very generous endowments have been settled on private universities, and why not on state universities especially for scientific research bearing on state development.

A near approach to the aims and purposes of our Association is the California Academy of Sciences. Some forty years ago James Lick, the founder of the Lick Observatory, made an an endowment to the Academy of $1,000,000, a large part of the income to go to maintain research in various fields.

Another suggestion may offer itself in the plan which the recently established Northwest Research Foundation adopted. This is reported in Science for October 13, 1933. It will be of interest to quote as follows from this report:

> "The way to a series of scientific researches that may open important and valuable industrial opportunities in the Northwest was opened at a meeting of the Board of Regents of the University of Minnesota, when that body approved the contract between itself and the Northwest Research Foundation. The foundation, whose membership is made up of leading business men of the Twin Cities and the Northwest, will raise a fund with which to investigate the commercial possibilities of regional raw materials not now being utilized to the full.
>
> "A campaign to raise funds for the foundation is expected to be launched shortly. It will be announced by the officials of that organization. James Ford Bell, chairman of the General Mills, Inc., is its head.
>
> "More than a year ago the University of Minnesota pointed out that such raw materials as lignite, the aspen or 'popple' forests of northern Minnesota, the peat deposits of this state, and the millions of bushels of grain of inferior grade that are a part of every crop, should be examined with

detailed care to determine what commercially useful products could be made from them. There are other materials, also, worthy of consideration, among them casein, of which millions of pounds are available in Minnesota creameries and cheese factories.

"The plan of the foundation is that it shall raise money to be turned over to the University of Minnesota for use in research. If a discovery is made and patented, it may be turned over to a manufacturing concern under a licensing system. From the proceeds or royalties from this license, the first money will be used to reimburse the donated fund for the cost of the research. In the second place, the donors will be reimbursed. Money over and above the amount needed for these purposes will be divided into two equal parts, half of which will go to the university outright, while the second half will go to the foundation as a fund with which to finance further scientific researches. Thus if a license should produce $100,000 after $10,000 has been spent on the original research, the foundation would get back its $10,000, the donors would be reimbursed in like amount for their donations, but without interest, and of the remaining $80,000 there would be $40,000 outright for the university and $40,000 to finance further researches for the foundation."

Should a research Foundation under a suitable name be organized by our Association, it could be administered by a representative committee and funds, as they become available, be allotted to the support of approved projects whether conducted at the various institutions or elsewhere.

APPENDIX

There follows a list of projects proposed in reply to the questionnaire sent out. The field of work into which the projects divide themselves is arranged in alphabetical order:

Administration

1. Administrative studies.

Agriculture

2. Soil survey.
3. Crop breeding other than cereals, alfalfa, sweet clover, etc.
4. Studies with grasses.
5. Weed eradication studies.
6. Erosion control on new project area.
7. Agronomic investigations to accompany erosion control.
8. Agricultural enginnering investigations to accompany erosion control.
9. Soil survey of Idaho.
10. Farm economic survey of main agricultural areas.
11. Barley for brewing purposes, manufacturing of malt.
12. Land classification, State of Washington.
13. Productive value of agricultural lands.
14. Market prices and receipts of truck crops.
15. Photosynthetic activity of apple leaves as influenced by certain factors.
16. Fundamental studies upon metabolic activities of fruits and vegetables with reference to cold storage response.
17. A study of the palisade worms of the horse.
18. Pasture studies in Inland Empire, with special reference to sheep and beef cattle.
19. A study of type in swine as influencing producer and processor.

Bacteriology

20. Effect of X-Rays on bacterial cells with special reference to mutations.
21. Undulant fever.

Biology

22. Ecology of Wallowa Lake.
23. General ecological survey of the entire Wallowa Mountains.
24. Study of the food and enemies of game fishes.
25. Dragonflies of the Northwest.
26. Forest protection from beetles of genus Dendroctonus.
27. Ecological survey of Umatilla County, Oregon.
28. Ecology of Crater Lake National Park.
29. Publication of detailed report on life of Flathead Lake.
30. Investigation of life in lakes of region adjacent to Flathead Lake.

BOTANY

31. A study of plant succession, particularly of range plants.
32. An ecological survey with a view to utilization of native vegetation to the maximum, for all purposes.
33. Extension of knowledge of fungus and algal flora of the Northwest.
34. A systematic study of the flora of Montana.
35. Taxonomic studies of some (or any) of the little-understood genera of the Northwest.
36. Tree ring investigation.

CHEMISTRY

37. To develop commercial processes for electrodeposition of manganese, zirconium, or vanadium.
38. Determination of iodine in northwest food products.
39. Influences of cases on colloids (for ultra microscope).
40. Conductance of dibesic organic acids (for special material and equipment).
41. Adsorption of gases on metals.
42. Thermal dissociation of organic compounds (for special apparatus and liquid air).
43. Alcohols containing trichlor-methyl group.

ECONOMICS AND SOCIAL SCIENCE

44. Archaelogy of the Great Plains and Plateaus.
45. Ethnology of the Plateaus with particular reference to social organizations.
46. Collection and proper preservation of Northwest historical records.
47. Indian studies; anthropology, ethnology.
48. The effect of the depression upon the public welfare movement in the Inland Empire.
49. The cost of judicial administration in the Inland Empire.
50. Present status of probation in the Inland Empire.
51. Tourist traffic in the U. S. A.
52. Land Utilization present and future.

EDUCATION

53. A plan of pupil guidance for the high schools of the State of Washington.
54. Size of high school in relation to service rendered.
55. A technique of determining the relative value of high school subjects.
56. School economics through the county unit.
57. The value of a supervising program in second class school districts.
58. The value of a supervising program in third class school districts.
59. The benefits of diagnostic-remedial teaching.
60. Guides for a student in preparing for quizzes.
61. Better scholastic aptitudes test for college freshmen.
62. Achievement tests for college seniors.
63. A complete audit of U. S. land grants to Montana and all endowments and endowmental earnings of the State of Montana from admission to the Union to the present.
64. A study of child health of 10,000 farmers' families now destitute.
65. Is the increase in class size in the public schools justified?
66. Survey of guidance methods and procedures in high schools of Inland Empire.
67. Study of scholastic pupil attainments of state institutions and private colleges in Inland Empire.
68. An equitable and efficient tax system for Montana for all purposes, including education.
69. The combination of teaching subjects in the training and assigning of high school teachers.
70. The consolidation of small school districts in Montana and its effect on cost and efficiency.

ENGINEERING

71. A study of the use of Idaho soils for rammed earth and adobe building construction.
72. A study of the use of castor oil for engine lubrication.
73. A study of the reclamation of engine lubricating oils by the individual farm user.
74. Lubricating value of automotive oils.
75. Cellulose sources and applications.
76. Scaling of P. C. concrete pavements.
77. Subgrade soil studies for this region.
78. Durability of concrete as influenced by changes in temperature and moisture.
79. Rural power line extensions for isolated farms.
80. Electrical survey of Idaho-rates, franchises, mapping of lines and plants.
81. Study of cedar poles as pertaining to high tension power lines.
82. Investigation of water used for boiler feed.
83. Investigation of fuel possibilities in farm and forest refuse.
84. Industrial survey with maps, etc., of all towns showing location of all industries.

FORESTRY

85. Land use in relation to forestry.
86. Forest land classification in value for timber growing, stock raising, recreation, water power ,etc.
87. Statistics (for drain) on amounts of forest timber and fuel wood used annually.
88. Cedar growth study.
89. Preliminary heredity study of western white pine.
90. Root systems of species in western white pine type.
91. Disease investigations—native fish and wild animals.
92. The economic aspects of forest protection in the Inland Empire. (a) Protection from fire; (b) Protection from insects; (c) Protection from diseases.
93. Study of economic possibilities of merging public and private timber holdings into large management units.
94. Study the life cycle of liver fluke in deer and its relationship to deer population and determination of practical control measures.
95. Study of food requirements (palatability, nutritive value, etc., of forage) and determination of the optimum dispersion of forage plants and brouse in relation to deer cover on winter range.
96. Electrical measurement of the moisture content of wood.
97. Determination of the heat insulation coefficient of standard types of roofing materials.
98. Native and tame range forage species for artificial reseeding.
100. Silvicultural effects of different methods of logging.
101. Silvicultural and nursery shelter belt practice studies.
102. The determination of the highest economic use of cutover lands.
103. The financial aspects of increasing the quality of residual stands of timber.
104. Securing adequate yield data on Douglas fir and western larch.
105. Decay studies on residual hemlock and white fir.
106. Studies of the honey mushroom in white pine stands.
107. Laboratory and field studies on the white pine blister rust.
108. Plasticization of lignin and of wood.
109. Formation of cellulose (or wood) products directly from sawmill waste instead of from purificd cellulose.
110. Fire and moisture proofing of wood and wood fiber products.
111. Technical study of western hemlock.
112. Technical study of lowland white fir.
113. Relation between method of slash disposal and subsequent protection costs.
114. Methods and costs of rehabilitating mishandled second growth stands.
115. Planting experiments on bushy land.

GEOLOGY

116. Relation of Idaho batholith to mountain building of the Northwest.
117. Faults and folds as loci of igneous intrusions.
118. Relation of major and minor structures in Western Montana.
119. Diatomite, asbestos, fuller's earth, and other non-metals.
120. Hot springs of Montana.
121. The origin of Montana place names.
140. Role of diffusion in ore depositions.
141. Stratigraphy of western portion of Snake River Plains.
142. Igneous metamorphism associated with the Idaho batholith.
146. Research on Cambrian paleontology.
147. Stratigraphy of central western mountain masses in Montana.
148. Petrography analysis of samples now collected of (1) All Algonkian rocks, (2) All Paleozoic rocks, in Western Montana.
158. Micro-fossils of the oil-bearing formations in Montana.
159. Distribution and mapping of the Pleistocene gravel deposits in Montana.
160. Physiographic history of Montana and its relation to placer deposits.
161. Mineralogic characteristics of Montana chromite deposits.
162. Structural and lithologic characteristics of the host rock of Montana batholiths.

HISTORY AND POLITICAL SCIENCE

122. Reconnaissance of source material on Inland Empire history.
123. Administration in typical counties in Idaho, Eastern Washington and Western Montana.
124. Clash between federal and volunteer troops in the Pacific Northwest.
125. Economic and cultural relations of Indians and whites.
126. Administration development in the Northwest states.
127. A history of mining organizations in the Northwest.
128. The relations between Parliament and the American Colonies.
129. Parliament and the English African Companies.
130. The status of the social sciences in Montana high schools.

Home Economics

131. New uses of wheat or wheat products in diet.
132. Vitamin content of cooked apple products.
133. The comparison of the copper content and copper availability of foods as cooked in the home in aluminum, enamel iron and copper—fresh, raw milk, cabbage and dried beans.

Mathematics

134. Certain phases of statistical work.
135. Problems in synthetic geometry.
136. Solutions of differential equations.

Mining

137. Properties of rocks (ores)—surface energy, gas occlusion—having bearing on crushing.
138. Properties of chemically pure metals, Cu, Zn, Pb.
139. Beneficiation of white clays of Northern Idaho.
143. Electro-Hydrometallurgy of copper flotation concentrate, of gold flotation concentrate. Production of electrolytic copper.
144. Electrolytic aluminum.
145. Electrolytic cadmium, beryllium, tungsten.
149. Ventilation.
150. Mechanical shoveling.
151. Drilling-timbering mining methods.
152. Determination of electrostatic charges on fine mineral powders treated with flotation agent.
153. Staining of highly polished surfaces of opaque minerals by selectively-shining agents to ascertain texture, composition and treatment (in order to separate associated minerals).
154. Chemistry of xanthates and related organic compounds used as flotation collectors.
155. Recovery of chromium by electrodeposition.
156. Age-hardening non-ferrous alloys.
157. Electrodeposition of alloys.

Pathology

163. Potency of food and pollen extracts.
164. Mode of entrance of B. Welchis.
165. Plant disease survey.
166. The relation of diseases to the failure of alfalfa stands.
167. Winter injury of wheat.
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A Preliminary Report on Recent Block Faulting in Idaho[1]

By Alfred L. Anderson

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INTRODUCTION

Normal or block faulting has been recognized in the southern part of Idaho, but that this type of faulting, which is largely responsible for the "basin ranges" in the Basin and Range physiographic province, extends far north into the Northern Rocky Mountains province and the adjacent Columbia Plateau province is not generally known (Fig. 1). It is true that the characteristic "basin ranges"—isolated, roughly parallel mountain ranges separated by desert basins—are generally inconspicuous or even absent, except near the Utah border and in the east-central part of the state, but there have been produced rather conspicuous tilted block mountains which have modified somewhat the plateau-like character of the mountainous area in Idaho, but have not destroyed it nor have they seriously altered the surface of the nearby Columbia Plateau. Much of the region to be described possesses characteristics common both to parts of the Basin and Range province and of the Northern Rocky Mountains and Columbia Plateau provinces, and thus represents a marginal zone between them. But on the whole its characteristics ally most of it with the Rocky Mountain and the Columbia Plateau province rather than with the Great Basin.

This paper is to serve as a preliminary report of the conparatively recent normal faulting in the state. Much field study is yet needed to delineate the limits of the faulting and to obtain complete details on individual faults. The paper will serve, however, to direct attention to this rather widespread structural phenomenon, which in the past has generally been ignored or overlooked. It is not possible to present all data in this preliminary report but only the most pertinent details.

The Snake River Plain (Fig. 1), which extends across the south part of Idaho, interrupts the continuity of the block faulting and serves to separate the region into two parts, one on the south, the other on the north, each of which will be treated as a separate geographic entity. Considerable data are already available on the southernmost part, but much that is to be presented on the northern part is based largely on personal observation and data yet unpublished. Merely a summary outline will be devoted to areas in which this type of structure has already been described, and for a more complete description the reader is referred to the original articles.

FAULTING SOUTH OF THE SNAKE RIVER PLAIN

Southeast Section

Mansfield[2] has given considerable attention to the Basin Range faulting in southeast Idaho and has proposed that the boundary between the Basin and Range and the Northern Rocky Mountains provinces be drawn eastward through the gap of Soda Springs

1 Published by permission of the director, U. S. Geological Survey, and of the Director of the Idaho Bureau of Mines and Geology. Presented at the annual meeting of the Northwest Scientific Association, Dec. 27-28, 1933, Spokane, Wash.

2 Mansfield, G. R., "Geography, geology, and mineral resources of part of southeast Idaho," U. S. Geol. Surv. Prof. Paper 152, 1927, p. 11.

and thence northward to the valley of Meadow Creek in the Henry quadrangle. From that locality he suggests that it be drawn northwest through the valley of Willow Creek and along the east side of the Blackfoot Mountains. This arrangement places Reservoir Mountain and Wilson and Pelican ridges, all of which he believes to be fault blocks, in the Basin and Range province. He describes many normal faults and explains that the most striking effect of normal faulting in the region is the production of horst and graben structure of which the Meadow Creek Graben is an outstanding example.[3]

Normal faults are also prominent features in the Portneuf quadrangle to the west and some of them, according to Mansfield,[4] were probably produced during the epoch of block faulting that gave rise to much of the so-called "basin and range" structure in the quadrangle of which the Chesterfield Range is an outlying representative.

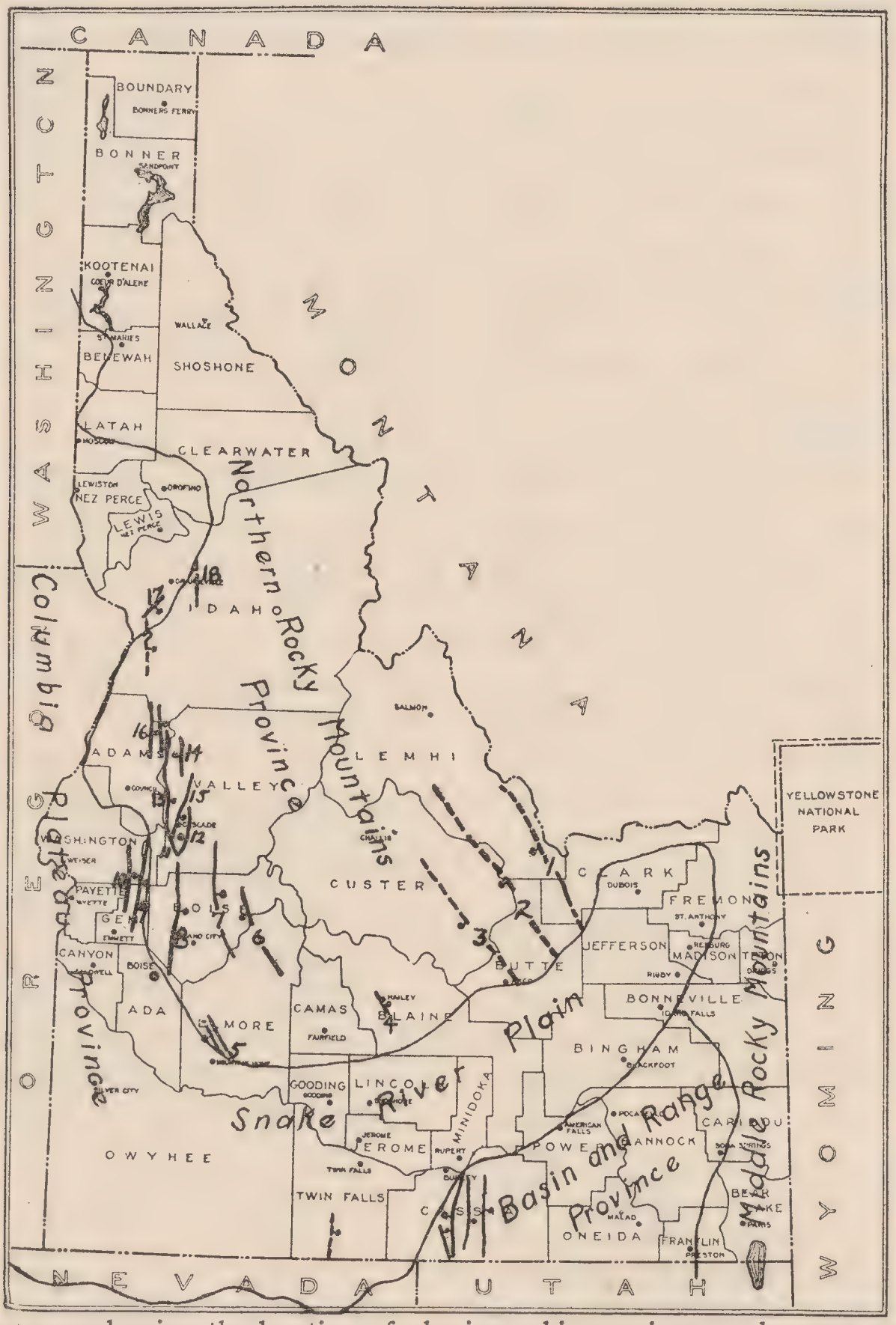

Fig. I. Index map showing the location of physiographic provinces and young normal faults.

Farther west in Power and Oneida

3 Idem., p. 162.

4 Mansfield, G. R., "Geography, geology and mineral resources of the Portneuf quadrangle, Idaho," U. S. Geol. Surv. Bull. 803, 1929, p. 62.

counties the Basin Range characteristics become even more pronounced and Piper[5] describes horst and graben structure (block faulting) as the dominant type of geologic structure. This has produced several parallel mountain ranges trending slightly west of north separated by wide flatbottomed basins known as Rockland, Arbon, Holbrook, and Curley valleys.

Mid-Southern Section

The same type of structure carries westward into Cassia County and there the writer[6] has described several ranges as belonging in the Basin and Range province. The most imposing range, the Albion Range, extends into Idaho from Utah to the Snake River Plain and is bounded on both sides by normal faults. It is separated on the west from South Mountain, a tilted fault block mountain, by an intervening basin, and on the east from Malta Range, another tilted fault block, by several alluvial basins. The Malta Range has a gentle dip slope to the west and a steep scarp slope on the east facing the broad Raft River Valley. South Mountain likewise has an abrupt eastward-facing scrap. Malta Range rises as much as 3,000 feet above the desert floor, and the Albion Range stands as much as 5,000 feet above the alluvial plain at its base. Smaller young block faults also occur; the one near Oakley with westward facing scarp and gentle, eastward dip slope is worthy of note. This block, and the Malta block, are composed of faulted Tertiary tuffs capped by quartz latite flows.

Goose Creek Valley, west of the Albion Range, separates the Basin and Range province from the Columbia Plateau province. The remainder of the state south of the Snake River Plain to the Oregon line is assigned to that province.

Basin Range faulting is not conspicuous west of the Albion Range, or, at least, has not seriously disturbed the plateau surface. There is, however, a marked interruption south of Twin Falls and from the writer's own observations the wide basalt and alluvium-covered plain extending from the Snake River Plain to the Nevada line appears to be bounded by fault scarps. The base of the scarp on the west side is marked by lava vents and thermal springs.

Southwest Section

Less is known of the structure in the southwest section, but Piper[7] writes that the volcanic series in Owyhee County was broken by normal faulting accompanying the formation of the Great Basin mountain ranges. Young faulting is also described in the Silver City region[8] in Owyhee County, where, according to Laney,[9] tilted fault blocks are much in evidence.

FAULTING NORTH OF THE SNAKE RIVER PLAIN

Eastern Section

There are several long narrow ranges in eastern Idaho separated by wide intermontane basins of the desert type that are a replica of the desert ranges in the Great Basin. These are characterized by straight valley fronts and faceted spurs on their west sides and are flanked by immense alluvial cones and fans. Beaverhead, Lemhi, and Lost River ranges are of this char-

5 Piper, A. M., "Possibilities of petroleum in Power and Oneida Counties, Idaho," Idaho Bureau of Mines and Geology Pamphlet No. 12, 1924, p. 6.

6 Anderson, A. L., "Geology and mineral resources of eastern Cassia County, Idaho," Idaho Bureau of Mines and Geology Bull. 14, 1931, p. 7-12, 80-83.

7 Piper, A. M., "Geology and water resources of the Bruneau River Basin, Owyhee County, Idaho," Idaho Bureau of Mines and Geology Pamphlet No. 11 (no date), p. 26.

8 Piper, A. M. and Laney, F. B., "Geology and metalliferous resources of the region about Silver City, Idaho," Idaho Bureau of Mines and Geology Bull. No. 11, 1926, pp. 43-51.

6 Laney, F. B., Personal communication.

acter, and Birch Creek, Lemhi, Big Lost River, Pahsimeroi, and Little Lost River valleys are well known intermontane basins flanking the ranges. All of these strike northwest and are approximately parallel to the regional trend lines.

Shenon[10] has pictured Birch Creek Valley as an arid, gravel-covered plain from five to eight miles wide with an average elevation of about 7,000 feet above which on either side grand mountain ranges, the Lemhi on the west and the Beaverhead on the east, rise sharply to elevations of over 10,000 feet. Deep valleys with almost precipitous walls have been carved into both mountain ranges. He then offers convincing evidence[11] that the region occupied by Birch Creek Valley was once a portion of the broad peneplain represented now by flat-topped summit areas, and that block faulting, (1)* in places with vertical displacement of over 3,500 feet, defined the wide valley through which Birch Creek flows. He also points out that the relatively straight clean-cut valley front, with well-defined faceted spurs extending northward into Lemhi County, indicate the extensive nature of the faulting and he suggests that further study will probably show that most of the intermountain troughs of western Montana and eastern Idaho have been defined by block faulting.

Meinzer[12] had earlier called attention to Pahsimeroi Valley as an arid-gravelly plain 40 miles long and from two to 10 miles wide lying between the Lemhi Range and the northern end of the Lost River Range, and to the fact that it represents a physiographic basin of the desert type such as the basins of Nevada, western Utah, and other parts of the Basin and Range physiographic province. He[13] also called attention to the contrast between the straight, well defined valley front on the east side of Pahsimeroi Valley and the indefinite border on the west, and suggested faulting (2) as the chief cause of valley depression. The straight valley front and faceted spurs are continuous features southward along the Lemhi Range to the Snake River Plain and the range is further bordered by Big Lost River Valley, another gravelly plain similar to the Pahsimmeroi and separated from it by a low divide. Both valleys are parts of the same linear depression. The most conspicuous feature of the Big Lost River Valley is the great size of the alluvial cones that lie at the mouths of the oversteepened canyons at the base of the Lemhi Range. According to the writer's own observations the physiographic evidence is all in favor of normal faulting along the west side of the Lemhi Range as the agency responsible for this range and the linear depression containing the two named valleys at its west base, but no opportunity has been offered for structural and stratigraphic confirmation.

Most of the features of the Lemhi Range are duplicated in the Lost River Range across Big Lost River and Pahsimeroi valleys. The Lost River Range also has a long gravelly plain known as Little Lost River Valley at its west base. It, too, has a straight valley front and well defined faceted spurs continuous from the Snake River margin to Mackay, a distance of more than 50 miles, and it may extend to Challis, an additional 40 miles. The range is flanked by a fringe of alluvial fans and cones of immense size debouching from the mouths of the oversteepened canyons. The writer has long held, although he has not previ-

10 Shenon, P. J., "Geology and ore deposits of the Birch Creek district, Idaho," Idaho Bureau of Mines and Geology Pamphlet No. 27, 1928, p. 3.

11 Idem, p. 5.

* Numbers refer to faults shown in Figure 1.

12 Meinzer, O. E., "Ground water in Pahsimeroi Valley, Idaho," Idaho Bureau of Mines and Geology Pamphlet No. 9, 1924, p. 5.

13 Idem, p. 15-16.

ously had occasion to express his view, that this range and the valley to the southwest have been defined by block or normal faulting (3). But there is stratigraphic and structural evidence that may be used to supplement the physiographic, although it has not been examined critically. Between Arco and Mackay a low group of hills lies between the base of the steep scarp and Little Lost River. The rock of these hills (Carboniferous) belongs stratigraphically above those at the base of the scarp (Devonian) and it was this relation that probably prompted Kirkham[14] to regard the Lost River Range as an overthrust block from the east. The writer, instead, would interpret this relation as an effect of normal faulting.

Hewett[15] suggests that the scarp on the west side of Big Wood River near Bellevue may be the result of recent faulting (4). The present course of the alluvial valley of Big Wood River here is uncommonly straight and does not deviate far from the trend of known normal faults, and, moreover, the facets of bordering ridges are most accurately aligned for seven miles or more south of Hailey. According to Hewett, owing to the difference in rocks, with a reference to their ability to resist weathering, one would scarcely expect to find such alignment, except as recent faults may limit the present valley. Umpleby, Westgate, and Ross[16] point out that most of the principal valleys and most of the side gulches near their mouths have slopes that are distinctly oversteepened near the base on one side or both sides. But they claim that it seems more probable that this widespread oversteepening in the lower parts of the valley profiles results from recent rejuvenation of streams by uplift or other cause rather than that these steep slopes are fault scarps. It is not clear to the writer how uplift could rejuvenate the lower stream courses tributary to the Big Wood River Valley without causing erosion and deepening of the main valley bounded by the scarp-like slopes. On the contrary, there is rejuvenation only on the scarp side while the basin side is receiving sediments. Such an abrupt change seems best explained by faulting as suggested by Hewett.

There are other basin-like depressions bordered by steep mountainous slopes in the eastern section. These ought to receive very careful study by field workers, for they too may be the result of comparatively young normal faulting.

Western Section

Mountain Home Region (5). A pronounced northwest-trending scarp composed of Tertiary rhyolitic lavas lies several miles northeast of Mountain Home. It has every appearance of a tilted block mountain with gentle northeast dip slope and steep southwest scarp slope. The scarp begins at the margin of the Snake River Plain and extends from it at an oblique angle for more than 18 miles and with a maximum relief of not less than 1,000 feet. Several streams are aligned parallel to the base of the backslope and there are landslides and alluvial deposits at the base of the scarp slope.

The old Mountain Home topographic sheet (1893) suggests another scarp of lesser magnitude parallel to the front of the main scarp. The tilted blocks are like those studied by the writer across the Snake River Plain in Cassia County. They are undoubtedly the result of normal faulting and are in the youthful stage of the ero-

14 Kirkham, V. R. D., "A geologic reconnaissance of Clark and Jefferson and parts of Butte, Custer, Fremont, Lemhi, and Madison counties, Idaho," Idaho Bureau of Mines and Geology Pamphlet No. 19, 1927, pp. 27-29.

15 Umpleby, J. B., Festgate, L. G., and Ross, C. P., "Geology and ore deposits of the Wood River region, Idaho," U. S. Geol. Surv. Bull. 814, 1930, pp. 70-73, 218.

16 Idem, p. 73.

sion cycle. The physiographic evidence of their presence is supported by structure and stratigraphy, for the same lava flows appear below and in front of the scarps as well as at the top of the blocks.

Deer Park fault (6). The name Deer Park fault is tentatively suggested for a major dislocation of north-northwesterly trend, recognized chiefly from the displacement of an old summit erosion surface. It has been observed a short distance east of the Banner district in Boise County and traced from the Payette River, about five miles east of Lowman to the south-southeast for not less than 30 miles, bounded everywhere on the east or north-northeast by a high scarp. The down-dropped surface is to the west and the displacement is not less than 500 feet and may exceed 2,000 feet in places. The fault crosses the North Fork of the Boise River near Deer Park Ranger Station, passes east of Granite Mountain, controls the remarkably straight alignment of Swanholm Creek and part of Phifer Creek, and extends along the west side of Steel Mountain. Its continuation beyond Steel Mountain has not been determined, but the alignment of Lincoln Creek suggests an extension from Rocky Bar to Featherville. Canyons have been carved deep into the down-dropped segment as well as into the upthrow block and for that reason basins, alluvial plains, etc., have not been formed.

The fault cuts massive rock of the Idaho batholith and it is therefore difficult to obtain evidence other than physiographic to prove its existence. The proof must depend largely on the abrupt termination of the old summit erosion surface at the scarp and its reappearance and continuation away from the scarp at the lower level. This relation also suggests that the scarp is a true fault scarp and not one formed subsequently by differential erosion —a fault-line scarp—for the erosion surface above and below is the same.

Deadwood fault (7). The Deadwood fault is approximately parallel to the Deer Park fault and lies from eight to 10 miles to the west, bounding the same depression described under the Deer Park fault. It also has dropped the summit erosion surface and the high side is on the west facing the Deer Park scarp. It produces the high steep slope on the east side of Sunset Peak and Pilot Peak, curves to the southeast in the direction of Barber Flat Ranger Station on the North Fork of Boise River, and, in the opposite direction, extends due north and crosses the Payette River about two and one-half miles west of Lowman. It continues up the valley of Deadwood River with the old erosion surface on the low block tilted westward to the scarp base and with the same surface on the high block, also tilted westward. It is probable that the fault passes along the west side of Deadwood Basin and may be largely responsible for that topographic depression.

The fault has produced in part a tilted block range, but the displacement, a maximum of about 2,000 feet, has been more than compensated by canyon-cutting in the relatively down-dropped segment between the Deadwood and Deer Park faults, and an alluvial basin has not been produced despite the fact that the high block is across the natural drainage of the region. Drainage adjustment to the faulting, however, is evident, for in the east or upstream side of the fault the Payette River has widened its canyon bottom and deposited gravels whereas in the journey across the high block below Lowman it has carved one of the steepest and most rugged canyons in the state. Intrusive rocks

only have been displaced by the fault and its recognition is largely in the straight alignment of the scarp, the abrupt displacement of the erosion surface, and the drainage readjustments. It is a true fault scarp.

Boise Ridge fault (8). The Boise Ridge and its continuation north of the Payette River as the North Fork Range is a pronounced topographic eminence beginning not far from Boise and extending almost due north to Round Valley, a distance of about 45 miles. It is essentially a single tilted block cut in half by the Payette River. The scarp slope faces east, the back slope west and at a more moderate angle.

The scarp bounding the east slope of the ridge has a somewhat sinuous curvature, but its general trend is due north. The old erosion surface constituting the summit area of the mountainous region is displaced and that on the east dropped and tilted against the base of the scarp. The same erosion surface also forms the crest and west slope of the block mountain. Two pronounced basins lie at the base of the scarp, one at the western part of Boise Basin, the other Garden Valley along the Payette River a few miles to the north. Lindgren[17] has called attention to faulting on the west border of Boise Basin and has pointed out its topographic expression and also the occurrence of Tertiary basalt and gravels on the crest of the ridge and their appearance at its base as faulted segments. The scarp west of Placerville in Boise Basin is very abrupt; the ridges are faceted and aligned on a straight line; active rejuvenation has occurred on the ridge so that all streams are oversteeped near their mouths; and large alluvial cones extend from the mouths of Canyon Creek and Trail Creek. Only for a short distance west and northwest of Quartzburg has the scarp been seriously eroded and modified by the combined work of West Fork of Granite Creek and its near neighbor in Confederate Gulch. The maximum relief near Placerville is about 2,500 feet.

Where the scarp bounds the west side of Garden Valley it is even more striking, for it involves a relief difference of from 3,000 to 3,500 feet. The faulting temporarily blocked the Payette River and caused deposition of gravels in the basin on the upstream side. But, as in the case of the Deadwood fault, the river has carved a profound canyon across the tilted block range across its path.

Boise Ridge and its continuation as North Fork Range are typical block mountains of youthful age similir to the tilted fault blocks in southern Oregon. The mountains are forested and therefore lack the desert characteristics typical of those in the Basin and Range physiographic province. Although the physiographic evidence is wholly in favor of faulting, it is not unsupported by stratigraphic and structural evidence, for the displacement of Tertiary basalt and gravel offer indisputable confirmation and from their relations prove that the scarp is a true fault scarp and not a fault-line scarp. The same basalt and the same surface upon which the basalt rests appear at the base of the scarp as well as at the top. This fault is otherwise similar to the Deer Park and Deadwood faults.

Squaw Butte fault (9). Kirkham[18] has called attention to the steep eastern scarp-like face of Squaw Butte and has presented it as a good field evidence for faulting. The scarp extends

17 Lindgren, Waldemar, "The mining districts of the Idaho Basin and the Boise Ridge, Idaho," U. S. Geol. Surv. Eighteenth Ann Rept. Part III, 1897, p. 657, 675.

18 Kirkham, V. R. D., "Igneous geology of southwestern Idaho," Jour. Geol. Vol. 39, 1931, pp. 573-4.

from the Payette River due north along the west side of Squaw Creek Valley for at least 35 miles. It is shown on the Squaw Butte topographic sheet as a little eroded scarp, forming the east slope of a tilted block mountain with a maximum relief of from 2,000 to 2,500 feet. This young range is not in the mountain province, but is out on the plateau area and consists of a tilted segment of Columbia River basalt. The same flows lie in front of the base of the steep eastern slope as on the crest of the ridge and therefore offer structural evidence of faulting and prove that the scarp is a true fault scarp.

There are other faults in this region and to the west, for according to Kirkham,[19] the plotting of basalt flows in a structure section drawn to the same vertical and horizontal scale, using actual dips, indicates notably discordant dips which can logically be explained by one or more gravity strike faults with the down-thrown side to the east in each case.

Big Flat fault (10). Another young fault is suggested on the Squaw Butte topographic sheet as lying to and west of Squaw Butte fault and bounding the west margin of a long topographic depression known as Big Flat. The south part of the basin drains to the south through Big Willow Creek, the north part to the north through Crane Creek. The ridge on the west resemble a tilted block mountain with gentle back slope to the west and abrupt scrap slope to the east, and therefore like most of the young block mountains of the region is bounded by a normal fault with downthrow to the east. The length as shown on the map is about 25 miles and the relief difference from 1,000 to 1,500 feet. The long block consists of a tilted segment of Columbia River basalt and is therefore similar to the one forming Squaw Butte.

There are other north-south valleys and ridges in the Weiser drainage basin to the west and these too may well be the result of block faulting. The writer has not had occasion to examine the area and therefore can not present evidence either for or against faulting, but in light of the structure in the adjoining area block faulting would most logically be expected.

Round Valley (11 and 12). Round Valley, a pronounced basin with nearly flat floor several miles east of Smith Ferry, is essentially encircled by high scarps except on the north where it is separated from Long Valley by a low group of hills (Meadows quadrangle). The basin is about six miles from north to south and two and one-half miles in the widest part. It is elliptical in plan and the bounding scarps rise to 1,000 feet above its floor.

The scarp (11) on the west side of the basin is apparently aligned with the Boise Ridge scarp and may be its continuation beyond the north end of North Fork Range. Another scarp (12) of equal magnitude bounds the east side of the basin. This gives Round Valley the appearance of a true graben. Scarps are so recent that they have been little eroded and entering gulches have only very small alluvial cones and fans at their mouths. It is probable that the floor of the valley is a recent lake bottom.

Long Valley (13, 14, and 15). Long Valley is the most pronounced topographic and structural depression in the west-central part of Idaho (Meadows quadrangle). It is about 38 miles long and extends in a northerly direction from Round Valley to the narrows of Payette Lake. Its floor is notably flat and is from six to seven miles wide. It is bounded by high

[19] Idem, pp. 573-4.

steep slopes on both sides, but the one on the west (13) is particularly pronounced and scarp-like in its appearance. The valley is floored with alluvium, mostly glacial outwash.

The steep scarp bounding the west side of Long Valley (13) has not been much modified by erosion. It is a continuation of one enclosing the west side of Round Valley and may therefore possibly be an extension of the Boise Ridge scarp. It describes a somewhat sinuous course, but the average direction is nearly due north. Much of the scarp rises above 2,500 feet above the alluvial plain at its base and reaches a maximum of 3,000 feet along its central part. West of McCall the scarp gradually decreases in size and finally disappears, possibly branching into several smaller step scarps of no great length. Mostly granitic rock is exposed in the face of the scarp, but Columbia River basalt lies at the crest of the block and the flows dip westward down the rather gentle back slope. Basalt of similar type and age is also known to occur at the base of the scarp beneath the alluvium and the topographic evidence of faulting is thereby supplemented by stratigraphic evidence.

East of and for a number of miles southeast of McCall the east side of the valley is flanked by a series of steplike scarps (14), each facing the east and with back slopes inclined to the west. Each succeeding scarp from the margin of the valley rises to higher levels. The scarps are comparatively recent and control the drainage, the streams following the depressions and therefore parallel to the margin of the valley. The scarps are surely the result of normal step faulting. It has not yet been learned whether the faults extend the full length of the valley along its east side, but part of the valley is at least so bounded perhaps most of it.

There is an interesting structural ridge in Long Valley, produced by a branch fault (15) which leaves the main western border fault about seven miles south of Cascade and extends northerly and diagonally across the valley into the mountains on the east side. This fault, which might be called the Beaver Creek fault, has produced a low block range extending across Long Valley with the downthrow to the east. The North Fork of the Payette River has carved a valley directly across the block and then flows parallel to it. The length of the fault as revealed by the scarp is not less than 12 miles and its displacements as measured from the top of the ridge to its base not less than 500 feet.

Several other ridges of great length lie east of Long Valley, but they have not been examined at close range. Their appearance from a distance, however, is suggestive of faulting and it is likely that normal faulting reappears here and there far into the mountainous area on the east.

Meadows Valley (16). Meadows Valley, another structural depression, lies about five miles east of the north end of Long Valley. It is more than six miles from north to south and about three and one-half miles from east to west. It is bounded on the west by a basalt scarp (16) from 200 to 500 feet high and on the east by the dip slope of the inclined downdropped block. From the top of the scarp the basalt dips gently to the west down the back slope of the ridge. The dip slope on the east side of the valley has been interrupted, however, by several step faults, in each case with the downthrow to the east. All scarps are very youthful and the faulting must have been very recent. Hot springs emerge from the base of the scarp on the west side of the valley. Meadows Valley is floored with alluvium.

The number of step faults between Meadows Valley and Long Valley have not been precisely determined nor their extent north and south of Meadows Valley. They are, however, conspicuous features of the landscape as are other prominent scarps of north-south trend between Meadows Valley and the Seven Devils region. Young block faulting is very well displayed and apparently wide spread in this general region. In every case asymmetrical ridges of tilted basalt segments have been produced—all bounded by true fault scarps on their east sides.

Grangeville region (17 and 18). A conspicuous basalt scarp (17) appears in the Salmon River Canyon southwest of Grangeville near Whitebird. This scarp trends about northeast and therefore is not parallel to the main general fault trend. It shows the maximum relief near the Salmon River a short distance below the town of Whitebird and disappears a few miles to the northeast near the top of Whitebird highway grade. The Columbia River basalt is displaced. The throw has been to the south, and this movement has resulted in a temporary blocking or checking of the Salmon River and the disposition of gravels now remaining as prominent terraces extending nearly to Lucile. The Salmon has carved a very narrow canyon across the block ridge below the mouth of Whitebird Creek.

There has been other movement in the Whitebird region and the basalt surface east and southeast of Whitebird gradually descends from elevations above 5,000 feet to 1,500 feet, almost to the level of the Salmon River and then abruptly regains its former high level on the west side of the river. It has not been determined as yet whether the abrupt change along the river is due to normal faulting or to a sharp monoclinal fold of north-south trend.

There has been faulting east of Grangeville and, according to Reed[20], Meadow Creek flows in a structural basin controlled by a young post-basalt fault (18).

No faults of the block type have been observed north of Grangeville in the plateau area, although notable warping extends as far north as Lewiston, Idaho. Neither have faults of this character been observed in the Clearwater and Coeur d'Alene mountains north of the Middle Fork of the Clearwater River, and the divide between the Selway and Locksaw rivers. The block faulting thus apparently terminates in the latitude of Grangeville, Idaho.

AGE OF THE FAULTING

The normal or block faulting in west-central Idaho has been comparatively recent for the scarps are exceptionally well preserved, and the block outline of the ridges is very little modified by erosive agencies. Many of the tilted blocks are of Columbia River basalt with intercalated fossiliferous Latah or Payette strata (upper or middle Miocene). Those that displace the old erosion in southwest Idaho have formed block mountains no more dissected than those of basalt and the faulting may therefore be of like age. The old erosion surface is no older than Miocene and may even be Pliocene. The late epoch of block faulting probably began rather late in the Pliocene and probably accompanied the widespread crustal unrest at the close of the Tertiary period. Movement probably continued into the Pleistocene, but the faulting had been completed, or largely completed, before glaciation inasmuch as some of the scarps have been somewhat glaciated and the basins outlining the depressed blocks partially filled with glacial or fluvio-glacial deposits. It had

20 Reed, John C., Oral communication.

also been completed before the deposition of at least the Lower Mesa gravels (Pleistocene) of Kirkham[21] for these show no break across the fault blocks.

Mansfield [22] has called attention to the recency of some of the faulting in southeast Idaho, part of which is Quaternary and affects Pleistocene basalt, and the writer[23] has also pointed out that the block faulting in Cassia County has affected late Pliocene and early Pleistocene erosion surfaces.

No exact age has been assigned to the faulting in the eastern part of the central Idaho mountains, but the youthfulness of the scarp and other attendant topographic features indicates rather recent age, probably late Tertiary and early Quaternary like that across the state.

Part of the recent normal faulting may represent rejuvenation or late movement along older fault lines, but it is yet too early to make any definite statements as to the influence of earlier structures. In south and southeast Idaho, the late normal faults are largely aligned in the general strike of the Laramide structures, but faults are also known to be somewhat oblique to the regional trend. North of the Snake River Plain the recent block faults are in part directed along earlier trend lines, but many are clearly independent features. In the eastern section there is close agreement between range elongations and the strike of the folded and faulted Paleozic strata. In the western area the faults are in part known to be more or less parallel to earlier trend lines, particularly those with northwest and possibly northeast strike, but faults with northerly strike transverse and oblique to all structures including the east-northeast shearing of the mid-Tertiary, as represented in the Boise Basin and adjacent areas, are apparently independent of earlier movement.

21 Kirkham, V. R. D., "Old erosion surfaces in southwestern Idaho," Jour. Geol., Vol. XXXVIII, No. 7, 1930, p. 661.

22 Prof. Paper 152, op. cit., pp. 162; Bull. 803, op. cit., p. 62.

23 Idaho Bureau of Mines and Geology Bull. 14, op. cit., pp. 87-88.

SIGNIFICANCE OF THE FAULTING

Late block faulting is relatively widespread in Idaho and extends well into the north-central part of the state. It is easily recognized in the mountainous area and in the adjacent plateau on the west where simple tilted block mountains, many of great length, flanked on their east sides by steep, straight, continuous scarps, have been produced. It has been recognized along the east side of the mountainous area where long, well-defined ranges, separated by broad alluvial basins like those in the Great Basin of Utah and Nevada have been formed. These eastern ranges, unlike those along the west border of the state, have straight well-defined valley fronts and faceted spurs on their west sides and are tilted to the east. It is interesting to point out, therefore, that along the western border of the state the fault scarps face mainly to the east whereas along the east side they face west, but the significance of this arrangement is not yet understood,unless due to collapse.

Much of the block faulting in Idaho is especially characterized by its youthfulness. Tilted blocks have been surprisingly little modified by erosive agencies and in this respect are like the better known fault block ranges in southern Oregon, which are regarded as the youngest in the Basin and Range physiographic province. All the scarps herein described are in youth in their first erosion cycle. The stratigraphic and structural relations prove that none of them are fault-line scarps.

Most of the young faults on both sides of the Snake River Plain are

aligned with the faults in Utah and Nevada, and belong to the same system of Basin Range faults which characterize the great physiographic province on the south. The alignment of these faults is more or less in the direction of earlier trend lines, but they cut the complex Laramide and older structures, and in Idaho also cut transverse Tertiary structural lines and the trend and gain of the Idaho batholith. The young faulting in Idaho is apparently a continuation of the Great Basin faulting and represents the progressive dying out of that faulting to the north. Its interruption at the Snake River Plain margin is due mainly to concealment beneath the young basalt flows which have partly filled the great structural downwarp. Some of the faulting may have been contemporaneous with the downwarp. According to the writer's interpretation much downwarping over the central and eastern part of the Plain area came rather early in the Pleistocene[24] and is progresively younger than that to the west. Even the young plateau basalt (Pleistocene) is noticeably downwarped near the Buhl and Gooding sections.

The faults are of the normal variety and imply an extension of surface. The cause of the faulting, whether to upthrusts, to collapse of a broad, unwieldy dome, or to readjustments to magma movement, is not known. The solution of the problem is regional in its proportions and for Idaho may be explained only when the broader features throughout the Cordilleran region have been properly interpreted.

ACKNOWLEDGEMENTS

The writer wishes to express his appreciation to Messrs. H. G. Ferguson and G. R. Mansfield of the U. S. Geological Survey for their critical reading of the manuscript; also to Dr. John W. Finch who read the manuscript at the Spokane meeting of the Northwest Scientific Association during the writer's absence.

24 Anderson, A. L., Bull. 14, op. cit., p. 88.

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SEPTEMBER, 1934

Vol. VIII No. 3

Published by

The Northwest Scientific Association

Single Copies Thirty-five Cents

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1000 Washington Ave. Brooklyn, N. Y., U. S. A.

NORTHWEST SCIENCE

A scientific journal published quarterly by the Northwest Scientific Association and devoted to the dissemination and promulgation of scientific effort in the Pacific Northwest

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NORTHWEST SCIENCE

Entered as second class matter April 5, 1927, at the Post-Office at Cheney, Washington. Office of Publication, Cheney, Wash.

Published quarterly at a subscription price of $1.00 per year, which includes the membership dues of the Association. Non members $1.00 per year. Vols. I (1927), II (1928), III (1929), IV (1930), V (1931), VI (1932), VII (1933), complete, each $1.25.

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NORTHWEST SCIENCE

Vol. VIII SEPTEMBER, 1934 No. 3

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Tertiary Floras of Central Washington[1]

(An Abstract)

By GEORGE F. BECK

State Normal School, Ellensberg, Washington.

What is perhaps the richest Tertiary flora in the whole Northern Hemisphere is found in central Washington. This is especially true when one considers the remarkable completeness of the sequence coupled with the fact that through the latter half of this sequence petrified forests occur along with and between the leaf horizons.

At the bottom of this Tertiary sequence lie the extensive Naches and Swauk lake sediments. Both carry an abundant flora. Exposures recently discovered at South Cle Elum, Easton and Snoqualmie Pass (Guye Formation) establish all three as members of the Naches formation. There is yet a possibility that the Swauk and Naches with their palm, fern, and exotic hardwood elements may be dropped down into the Cretaceous.

The Roslyn and Manastash formations carry abundant plant remains and are coal bearing. Both have been referred to and will probably remain in the Eocene.

At this point there is a clear break to the more temperate type of flora associated with the Columbia River lavas of the mid-Tertiary. Fossil woods appear in the basal flows and continue up through to the uppermost, but it is at a horizon some 500 feet from the top that the most extensive sedimentary beds appear. Here are found the Kittitas flora, leaf beds Latah in type, and the remarkably close correlated Vantage Petrified Forest. Both represent clearly a geographical transition between the Latah of Grand Coulee and the Eagle Creek of the Columbia Gorge. This is observed especially in the change from the red oaks of the Latah to the white oaks of central Washington.

Petrified woods are abundant in the upper flows of the Columbia River lavas, but it is in the overlying Ellensburg sediments that leaf horizons reoccur. (A beautiful flora was exposed and sealed in again in the Moxee-Selah irrigation tunnel which passed through the upper few hundred feet of the Columbia River lavas). Additions to Knowlton's original flora of the nineties bring out the fact that the Ellensburg floras instead of being referable to the Latah or Mascall are clearly comparable to Dorf's Pliocene floras of California. This is in accordance with their stratigraphic position above the Kittitas flora.

In support of the above argument the writer has collected and studied in a preliminary way some 3,000 leaf prints from a score of leaf horizons, and 2,000 wood specimens (850 having been thin sectioned) from 66 localities.

[1] Presented at the annual meeting of the Northwest Scientific Association, Dec. 27-28, 1933, Spokane, Washington.

Origin of the Washington Scablands[1]

By Edwin T. Hodge

Oregon State College

Introduction

In the northwestern part of the United States is a strange and unusual topography that is unduplicated in any other known part of the world, a fantastically eroded basalt surface known as the Scablands. Lying on or between the Scablands are great deposits of loess-like soil.

All of the above occurs on so grand

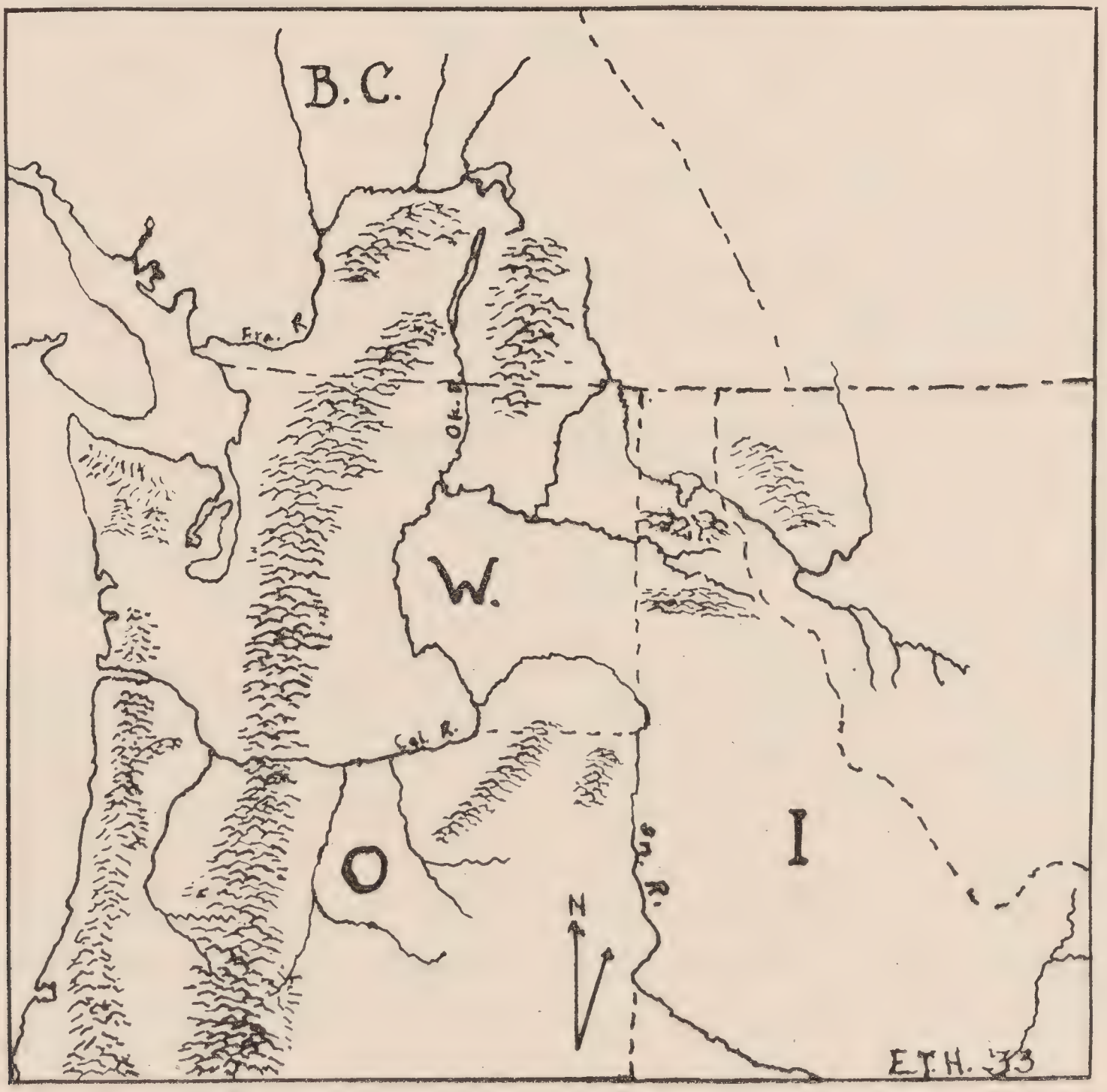

Figure 1. Location of Scablands and contiguous features.

Figure 1. It is characterized by great waterless canyons, waterfalls and pot holes. These are associated with widespread perched erratics, thick gravel plains, upstream dipping torrential gravel beds and peculiar gravel terraces and bars. The above occur on a scale that individual features are comparable in size to those described in any part of the world. The main area of Scabland alone occupies one-fourth of the State of Washington.

Many theories have been offered to explain this remarkable region, but of these only that of Bretz[2] has been stated fully in many papers and therefore widely accepted. Bretz would explain all of these features of the

1 Presented at the annual meeting of the Northwest Scientific Association, Dec. 27-28, 1933, Spokane, Wash.

2 Bretz, J. Harlan. The Grand Coulee; Amer. Geog. Soc., Special Publication No. 15, 1932, Chapter 4, pp. 39-83.

Scablands by one all inclusive event: a single great flood or a series of great floods occuring within a short period of time and to which he has given the name *Spokane Flood*. His theory implies that the Scablands are the result of a single brief episode of the Pleistocene. In contrast with Bretz' theory I offer as an alternative hypothesis a theory wherein the history of the Scablands is considered an integral part of the late Tertiary history of British Columbia, Idaho, Washington, Oregon and Nevada. The genesis of the Scablands is related to the origin and integration of Columbia River. As such their true explanation is of fundamental importance in all problems related to the American Northwest from the Miocene to the present.

History of the Study

The author became interested in this study in 1916 in British Columbia where the amazing interrelationships of the Frazer and Columbia rivers and their complex history were first manifested. Continuous investigation since then in the American Northwest shows the profound Pleistocene modifications of their drainage systems. In 1931 the American Association for the Advancement of Science provided the author with funds for the purpose of making a special investigation of the Scablands. As a result, the hypothesis below was formulated. The story was tested against additional evidence in 1932.

Suggested Explanation

The outline of the story given below may be considered the first formal report of the investigation supported by the American Association for the Advancement of Science.

The explanation offered considers the Scablands and related features to be the result of a long and complex series of events. The successive events were so numerous, and a complete description of each would demand so much space, that it is considered advisable at this time to give only an outline of their history.

Pleliminary Stage

1. The Columbia River basalt formation (Coriba) was laid down, folded and eroded generally to a stage of youth, but in places to that of maturity, Figure 2. This surface (Coriba surface) was complicated by the issuance of the Spokane olivine basalts and still later by intracanyon lavas and by the deposition of intervening lake beds (Latah?). The Snake River if it flowed over this surface did not cross the Horse Heaven Hills. The Upper Columbia River, then, found an outlet by way of Okanogan Valley to the Fraser River and thence to the Pacific Ocean. The other streams on Coriba surface occupied structural basins between the Horse Heaven Hills, Saddle Mountain-Washtucna, Waterville-Adrian and the Sanderson-Cheney folds. Because Coriba surface extended westward without any important geographic change and because the Pliocene, Pleistocene and Recent volcanic piles which make up the Cascade Mountain did not exist, the above streams may have flowed directly to the west and debouched into the Pocific Ocean. These streams all flowed at a higher level than their present entrenched gradients.

2. The late Pliocene and early Pleistocene pyroclastics and lava flows erupted along the course and were the cause of the present Cascade Mountains in Washington and Oregon. They dammed the westward flowing rivers of southeastern Washington. The torrential beds derived from these volcanics formed a great pedimont fan deposit on the east side of the Cascade Mountains (Ellensburg formation). Lake beds (Ringold formation and others) which grade into the upper torrential beds were formed farther

east in the lakes formed by the ponded rivers. The Upper Columbia River was not dammed.

First Ice Advance

3. The Okanogan glacier advanced southward down the valley, dammed

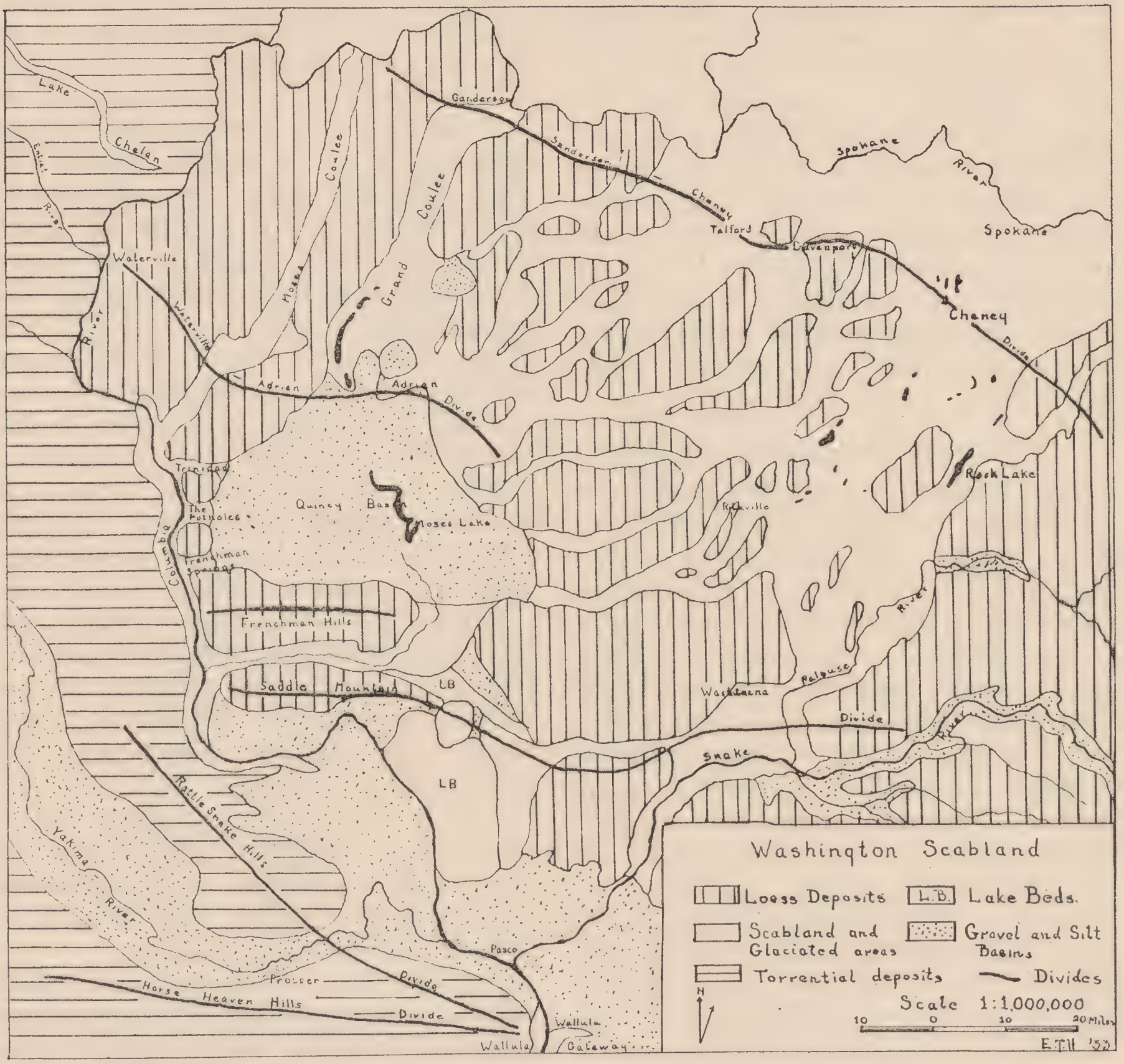

Figure 2. Place map of the Scablands.

off the ancestral Upper Columbia River, which ponded north of the Sanderson-Cheney divide.

4. The ponded river spilled southward over the Sanderson-Cheney divide through the cols that had been cut by its south side tributaries. These cols were cut lower and lower, and valleys were eroded southward to the next consequent stream flowing westward on Coriba surface. These valleys later directed the course of the Ice that later filled them.

5. During three glacial epochs glaciers moved towards the Scabland region from the west, north and east.

a. The western glaciers, south of Lake Chelan, may not have reached the present position of Columbia River or at least had no important part in our theory.

b. The northern glaciers transgressed the Sanderson-Cheney divide at four places.

c. The eastern glaciers did not reach the Scablands.

6. The First Ice Advance, or Cheney Ice (Kansas?) had effects as follows:

a. The Okanogan ice lobe enlarged a spillway col and an old tributary valley (4 above) (Moses Coulee) in Coriba surface.

b. After the Okanogan ice had advanced up Upper Columbia River to the upper end of another valley (Grand Coulee), it diverted all Columbia for a long time through this spillway and cut it deeper than Moses Coulee. The ice then advanced down this spillway and deepened it.

c. Thin, wide sheets of ice advanced down Telford and the Cheney passages. Note that Grand Coulee lay between the two sources of ice.

d. The Okanogan ice finally became confluent with ice that descended the other northern valleys, and the Cheney ice may have extended as far south as Ephrata and Ritzville.

e. The ice eroded chiefly by plucking on a basalt surface. The basalt was broken into brick-bat pieces and fed to the glacier streams which transported the small pieces easily.

f. The ice plucked deeply, producing basins which were constantly enlarging at their upper ends. They were filled by ice beds, which, remaining stagnant after the retreat of the ice lobes, prevented them from being filled by glacial debris.

g. The ice moved rapidly without much plucking over smooth inclined surfaces.

7. Within the closed basin, hereafter called the *Scabland Basin,* formed by the Chaney Ice front, the mountains of Idaho, the Horse Heaven Hills and the Cascade Mountains, the melting and retreating ice formed Lake Lewis. The lake beds deposited in Lake Lewis are found as far east as Fishtrap and as far north as Orondo and up to an elevation of 2300 feet. Some lake beds north of the Sanderson-Cheney divide may have been formed at this time. These lake beds along with those of 2 (above) served later to superpose all streams across the folds 1 (above).

8. In the meantime in Oregon and to the south of the Horse Heaven Hills the ancestral constituents of Columbia River also had been dammed by a piedmont fan (Dalles formation) on the east side of the Cascade Mountains. Condon Lake was the result and in it were laid down the Shutler beds.[3]

9. Condon Lake and Lake Lewis united, and their water spilled at 1900 feet in elevation over the Ortley divide and a consequent course across the Cascade Mountains.

10. This produced the present superposed discharge way of Columbia River which as it entrenched its course, drained Condon Lake. Lake Lewis held behind the Horse Heaven Hills at a still higher elevation spilled over the Wallula col and cut Wallula Gateway into the Lower Columbia River which, with the added supply of water has continued its entrenchment since that time.

11. As Lake Lewis shrank in size the Snake River extended its course and eventually was led into the Columbia River. In like manner all other rivers of the Scabland Basin, having but one outlet were integrated and Columbia River came into existence.

12. Icebergs, calved from the Cheney Ice lobes in northern Washington, floated over the slowly lowering surfaces of Lake Lewis and Condon Lake and stranded and melted. Thus were dispersed the highest erratics. The Cheney Ice eroded vigorously only in northern Washington, British Columbia and Idaho hence

[3] Hodge, E. T. Columbia River Fault; Bull. Geo. Soc. Amer., Vol. 42, No. 1, pp. 189, 1931.

the erratics that are "foreign" material. The erratics were carried down Columbia River into Oregon. The easily fractured basalt did not form erratics, but was carried as stream gravels.

13. The lake beds of Lake Lewis were deposited with no determined unconformity on the older lake beds. Together the lake beds buried Corbia surface and obliterated all traces of the older drainage pattern. These beds lay below the original spillway of Lake Lewis and within the Scabland Basin, hence they were only subjected to erosion after Lake Lewis had been drained. Consequently the drainage from the stagnant Cheney Ice flowed over a large bed surface in courses quite independent of the structure of the pre-lake bed formation. The courses of the new stream were determined (x) by the sources of water, (y) by the Wallula Gateway and (z) by the steptoes of Pre-Cambrian, Jurassic and Coriba rocks. The result was (a) Snake River followed the north side of the Horse Heaven Hills to Wallula Gateway, (b) the streams flowing down the east side of the Cascade Mountains eventually followed the shortest course southward along the east side of the piedmont fan to Wallula Gateway, (c) Upper Columbia River, blocked by the Okanogan glacier followed Cheney, Telford, Grand Coulee and Moses Coulee outlets in southwestern courses over the lake beds to the united river of (*b*) above.

14. These streams entrenched into the lake beds, piedmont fan deposits and younger lavas and finally were superimposed upon the geometric and structural elevations of the original Corbia surface.

15. The lake beds were eroded dendrically. That is the thin headward or northeastern areas of lake beds were easily stripped away from the outer or upper portion of the Scabland area and only small remnants were left, but in the lower western and southern area large flat patches of lake bed in the interstream areas were preserved.

16. The Cheney Ice became stagnant and in melting produced correlative effects as follows:

a. The melting water carried icebergs and dispersed erratics.

b. Stagnant ice filled deep holes and kept them from being filled by outwash debris.

c. Where the lake beds were thin and lying above buried ridges in the Coriba surface the streams were superposed, cut narrow and produced the Arlington type of channel.

d. The gravel formed chiefly from brick-bat basalt was spread by the discharge streams over the western and southern portion of the area, and filled the Quincy and Umatilla Basins.

e. The characteristic braided streams of melting glaciers flowed southwestward (see *13c* above) over the lake beds. Ice occurred in the constricted channels cut in the lake beds or in the denuded basalt surface. These jams caused the channels to anastomose. The differential erosion in the anastomosing channels plus the plucking by stranded icebergs and by frizzle ice, produced the most characteristic feature of the Scablands previously described as moraine-like deposits near Arlington.[4]

f. The glacial streams were diverted by the ice-jam dams and cut new channels which in some cases were cut deeper than the dammed channel and formed a permanent diversion, and an abandoned perched channel. The reverse also took place.

g. Water falling over ice jams pro-

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[4] Hodge, E. T., Exceptional Morainelike Deposits in Oregon, Bull. of the Geol. Soc. of Amer., Vol. 42, pp. 985-1010, 1931.
In this paper the writer first announced his theory that the Scabland features were principally caused by iceberg jams.

duced great pot holes and / or falls.

h. Dammed channels became flooded and in some places spilled over upstream divides and produced in their own tributaries up-valley dipping foreset beds and other types of perched deposits.

i. Ice jams produced moraine-like deposits from the gravels by crowding icebergs.

17. The stagnant Cheney Ice and its glacial water produced kames, eskers, pot holes, falls and perched gravel deposits.

18. The retreat of the Cheney Ice was complete in the Cheney and Telford passages, stagnant in Grand Coulee, and incomplete in Moses Coulee.

Second Ice Advance

19. The ice retreated from upper Columbia Valley but remained in the Okanogan Valley. Hence the water spilled westward into ancestral Chelan-middle Columbia Valley (see *13b* above) and continued to flow in this course until a canyon was cut below the level of the outlets through Sanderson-Cheney divide. This union of the Upper Columbia River, and those ancestral rivers previously joined, completed the integration of Columbia River. The deeper canyon cut by the well fed Columbia on the east side of the Cascade Mountains (see *13b* above) gave an advantage to this spillway as compared to the choked, divided and slightly entrenched spillways of *13c* above. Hence it cut down so deep that the latter lost all of the water and became for the first, but not the last time, the dry water and glacial courses as we find them today.

20. The concentration of the glacial waters of northern Idaho, British Columbia and the eastern Cascade Mountains slopes, added to the combined waters of the Snake, Umatilla, John Day and Deschutes rivers, caused the integrated Columbia Canyon to be rapidly entrenched below the level of the lake beds and into Corbia surface. In many places the river was superposed into large folds. The Pasco Basin was eroded.

21. The Second Ice, or Spokane Ice, advanced and again like the Cheney Ice formed a lobular front producing the following effects:

a. Okanogan lobe transgressed Columbia River, dammed it and diverted water through Moses and Grand Coulees.

b. The Spokane lobe revived the Telford and Cheney northeast-southwest channels (see *13c* above).

c. Ice jams in the Moses Coulee, Grand Coulee, Telford and Cheney channels and in their dependent channels reproduced and enhanced the effects of the Cheney Ice advance. We do not know whether the first or the second glacial advance produced the greatest amount of Scabland, but we are of the opinion that the second advance of ice was the most effective.

d. Glacial-fluvial debris, at the time of the ice's furthest advance, filled the depressions south and west of the ice front. Stagnant ice prevented the proximal depressions from being filled with debris upon the ice's retreat.

e. The material eroded from lake beds and the fragmental basalt plucked from bed rock was carried by the swift water into the main streams. This debris was not piled up as moraines.

f. Columbia Canyon had now been in existence a long time and had, since its integration, carried most of the water. Hence the revived Scabland channels had to spill into it. The erosion of the basalt produced great volumes of pebbles. The gravels were deposited as deltas at the mouths of tributary streams. In the lower part of Columbia Canyon the gravels formed a thick flood plain. This plain

was built up by seasonal floods and, since the flood waters from the Upper Columbia River always were in great excess of the small discharge of the tributaries in its lower course, the gravels were carried up the tributaries. These gravels therefore show torrential upstream bedding. The gravel flood plain has since been dissected into high terraces. Gravel bars were formed in the lee of defending rocks and below the end of a rock divide between two confluent streams.

g. More erratics were spread but at a lower elevation. These later erratics are much younger than those from the Cheney Ice.

22. The melting, stangnant ice yielded loess which was carried by wind and deposited upon all interstream areas. The loess blanketed much of the old surface including the older lake beds. In many places the loess was laid down in water and bedded.

The Third Ice Advance

23. The Third Ice advance (Wisconsin?) did not advance as far as the other two ice fronts. It produced the following effects:

a. It scoured, scrubbed and cleaned the northern surface. The gravels so produced were added to those referred to in *21f* above.

b. The melting peak of the Third Ice occurred after the gravels of the above paragraph had been discharged. This slightly loaded water was augmented by the water freed from Lake Missoula and other lakes when the ice retreated far up the northern valleys. All of this water was concentrated in Columbia Canyon and consequently the gravel flood plain (*21f* above) was cut into high terraces.

c. At a very early stage, when only a narrow channel had been cut in the gravel flood plain, icebergs formed in the channel. These and the frozen surface of the river during the winters caused ice-shoving which pushed the gravels of the flood plain up into levee-like walls on either side of the stream and formed fossae adjacent to each rock bound valley wall. Overflow around the ice filled channel and its gravel dikes, as well as water from tributary streams, deepened the fossae. Such fossae are notable in the lower canyon within the Scabland Basin.

d. Icebergs transported erratics, formed iceberg jams and further elaborated the anastomosing channels and Scabland features.

e. The glacial-fluvial waters flowing through the Moses Coulee, Grand Coulee, Telford and Cheney outlets swept the upper channels clean, meandered over the gravel plains, and filled flush with the general surface the Quincy and Pasco Basins.

f. The same water cascading into Columbia Canyon cut waterfalls which, by reason of the long duration of this final glacio-fluvial stage, were large and retreated a long ways up the tributary streams, especially at Trinidad, The Pot Holes and Frenchman Springs. Falls and pot holes were also formed where the water cascaded over iceberg dams or stagnant ice in the upper channels.

g. Fresh erratics were dispersed and dropped at lower levels than those of the two older stages.

h. The glacio-fluvial waters eroded the sides of the interstream loess hills. Some of the loess was redeposited in some of the abandoned stream courses.

i. Great quantities of gravels were carried westward and deposited in the Portland alluvial fan and for a time the Portland delta.

24. The ice made its final retreat up the valleys outside of the Scabland Basin. In its retreat it has left interesting and widespread effects of stagnant ice, glacial damming and stream diversion.

Conclusion

The events are listed above as twenty-four in number only as a matter of convenience. There were many other important, intervening steps in this long sequence of events. The Scablands were not, according to this explanation, produced in a few months or years by one or a few catastrophic floods. They are the result of a long period of time dating from the Miocene to the Recent. The agencies were ice and glacial waters. The method was not that of glacial ice and glaciofluviatile waters as generally described. On the contrary stagnant ice and iceberg jams, associated with water, were the important methods employed.

A basaltic surface in part protected by lake beds provided a special material to erode. The work was done in a region of hot summers and cold winters. The progress of the work was slow and involved many repeated attacks by the various agencies as the glacial ice advanced and retreated three different times over hundreds of thousands of years. Taken as a whole the methods employed were the common and usual methods that one may see at work today or resason to have been at work in many places in past time. The phenomenal features produced by these normal methods resulted from an unusual geomorphic and geologic terrane.

Glacial Drainage Channels in Ferry, Stevens, and Pend d'Oreille Counties, Washington[1]

By Otis W. Freeman

In Northwest Science for September, 1933,[1] the writer described features of the Okanogan Lobe of the Cordilleran Ice Sheet, with particular attention to glacial drainage channels that were associated with stagnation of the ice in the Okanogan region. The present paper describes glacial drainage changes and overflow channels in Ferry, Stevens, and Pend d'Oreille counties in northeastern Washington.

Previous work in this area has been done by the following:

Thomas Large[2] describes glacial "Lake Clark" that once lay between Newport and Metaline Falls in the Pend d'Oreille Valley. This lake was about 60 miles long and 6 miles wide with occasional constrictions. The post glacial outlet of Lake Clark was by way of the Little Spokane Valley into the Spokane River near Nine Mile. Large believes that Lake Clark lasted until recently and that the modern outlet cut at Z Canyon drained the lake only a few centuries ago.

Charles E. Weaver[3] mentions glaciation in Stevens County. Following Day and Dawson of the Canadian Survey he states that the Cordilleran region in Canada between the Cascades and Rocky Mountains was almost completely covered by an ice sheet 300 miles wide and thousands of feet thick. South of the 49th Parallel the front of the ice cap broke up into a number of lobes which traveled southward along the larger valleys and in southern Stevens county deployed out onto the lava plateau. Associated with these lobes are large terraces, outwash deposits, and moraines. Pre-glacial drainage lines were choked and shifted so that streams rarely occupy their former sites. Weaver states that ice lobes occupied the Kettle Valley, Columbia Valley, and Echo Valley through Colville Valley to Loon Lake with a lobe eastward through Little Pend d'Oreille valley. The present writer believes that much erosion in the valleys mentioned by Weaver as filled with ice resulted from glacial river erosion rather than ice erosion. Evidence for this will be given later.

Olaf P. Jenkins states about Pend d'Oreille and Stevens Counties[4]: "The larger valleys of the region probably represent the positions of the large ice lobes which occupied and re-occupied the trenches more than once during the Ice Ages. . . . Deposition of sand and gravel by the huge glacial streams was also due to the presence and rapid disappearance of the ice. Innumerable lakes were also formed by glacial action and drainage was entirely altered."

In the Okanogan Valley the writer has described[1] the numerous overflow channels that carried water from lakes located along the stagnating glacial lobe that occupied the trench there toward the close of the glacial period. Little evidence that would definitely prove ice stagnation has been found in the area covered by the present paper. The eskers and kames of the Waterville Plateau and numerous pit lakes and potholes associated with the gravel terraces of the Okanogan region are very scarce in the Colville and Pend d'Oreille Valleys.

Channels in Ferry County

The principal glacial drainage channel in Ferry County, the Kettle-Curlew-San Poil trench, extends from beyond the Canadian boundary to the Columbia. As mentioned by Pardee[5]

1 Presented at the annual meeting of the Northwest Scientific Association, Spokane, Washington, Dec. 27-28, 1933.

and others the San Poil Valley probably contained a very large stream for a time. The valley has a Y shape. The top of the Y is the valley of the Kettle River. At Curlew the channel extends southwards by way of Curlew Creek and Curlew Lake to Republic and thence via San Poil River to the Columbia River. Toward the close of the glacial period as the ice wasted away but still lingered near the Canadian border, blocking outlets there, the melt water drainage was southward to Lake Nespelem that occupied the Columbia Valley east to the ice dam across the valley at the mouth of the Okanogan. As proved by silt deposits Lake Nespelem filled the San Poil Valley at least 2-3 miles above Keller. The divide between Curlew Creek and the San Poil can hardly be distinguished. The elevation of the divide is 2,360 feet. Terrace gravel deposits can be traced all the way from Canada to the Columbia. In many places a southward dip shows in the gravel indicating that the glacial stream current flowed from the north although present drainage is from the south from Curlew Lake into Canada. Five or six terrace levels can be distinguished in the deposits of this main north-south running valley. Umpleby[9] mentions that lateral moraines were left in the valley by a tongue of ice that extended down the valley at the time of its recession. Originally the ice was at least 3,000 feet thick in the valley since mountains like Granite Mountain (5,326) have been glaciated. A mass of ice a few miles in length probably stagnated and lingered for a time in the Curlew Valley. During the recession of the glacial lobe a glacial lake developed in front of the ice around the present Curlew Lake. As the outlet channel to the south was cut down the level of the lake decreased.

A minor high level channel extends from Tonasket in the Okanogan Valley up Bonaparte Creek through Aeneas Valley and the west fork of the San Poil to the San Poil Valley. The high point in the divide in Aeneas valley is about 2,600 feet elevation. The divide in Aeneas Valley is several miles wide and consists of heavy moraine and outwash deposits. This channel may have served as temporary outlet of melt water around Tonasket when the Okanogan Valley below this point was blocked with ice. It is possible that a block of ice stagnated or a minor lobe terminated in Aeneas Valley; in either case for a time there may have been simultaneous drainage west to the Okanogan and east to San Poil.

Channels in Stevens County

One main channel extends down the Kettle and Columbia Rivers from Canada along the west border of Stevens County. This is joined at Kettle Falls with the large Columbia Valley from the northeast. The Colville Valley to Springdale and thence via Chamokane Valley to Long Lake, comprises a second principal glacial outlet channel. In addition at least four minor channels connect the upper Columbia Valley with the Colville and one obvious channel from Tiger to Arden through Little Pend d'Oreille Lakes connected the Pend d'Oreille and Colville valleys.

The field evidence suggests that glacial lobes remained in the Columbia and Colville valleys for a considerable time. The Columbia lobe presumably terminated in Lake Nespelem which in turn drained through the Grand Coulee. The Colville lobe ended in northern Spokane County. During the recession of this lobe large quantities of melt water drained southward. The western channel followed Chamokane Creek through Ford to the Spokane Valley. An eastern channel carried melt water through Loon Lake, Clayton, and Deer Park, to the

State Normal School, Cheney, Washington.

Principal glacial lakes and drainage channels of Northeastern Washington. This map shows channels for Okanogan County described in Northwest Science for September, 1933, as well as for the accompanying paper. For the ice front and scablands south of this area see map by Bretz in Geographical Review, Vol. 18, No. 3, 1928.

Little Spokane Valley. Broad gravel outwash plains were built up north and east of Deer Park, and in an area cornered by Springdale, Valley, Deer Lake, and Loon Lake. This outwash varies in elevation from 300-800 feet above the Colville Valley. The gravel has buried the bases of some hills, like Jump Off Joe Mountain, and forms the dam for Deer Lake on the west and of Loon Lake on the north. A small temporary lake probably existed around Clayton.

Upon the retreat of the ice northward a lake developed in the southern Colville Valley. The lake drained into Chamokane Valley over a ledge of 2,000 feet elevation. On the 2,000 contour this glacial Lake Chewalah had a width of 5-6 miles, and a depth of around 300 feet near Chewalah. Chewalah Creek built a delta into this glacial lake. At Arden the lake received melt water from the Pend d'Oreille glacial lobe through the Little Pend d'Oreille spillway which has a maximum elevation of about 3,200 feet. Lake Chewalah was drained and the southern outlet abandoned when the Colville lobe had retreated north of Colville exposing a lower spillway from Colville to Kettle Falls which is followed by the Colville River of today.

The Colville Valley depression continues north about 10 miles, the length

of Echo Valley. Echo Valley carries no drainage today but in glacial times quantities of water flowed there. Echo Valley has a broad outlet west to Bossburg on the Columbia and a narnow channel north to the same river that here make a large bend. That spillway collected melt water from two sources about three miles apart. When ice lingered in the Columbia trench lateral melt water lakes developed that rose until they overflowed southward toward Colville. Besides the Echo outlet three other well defined glacial channels existed west of Northport. A mile east of Northport there was a spillway up Onion Creek and down Clugston Creek to Echo. A spillway extended southeast up Deep Creek to the forks near Hansen School where it was joined by another spillway that leaves the Columbia at Boundary and continues up Cedar Creek and Lead Point to the junction. The united channel, that may be called the Aladdin spillway, goes south to Aladdin and southwest to Colville, crossing the Deep Creek—Mill Creek divide at an elevation of about 2,766 feet. For water to flow over this divide, which before erosion was still higher, required deep marginal lakes in the upper Columbia Valley. Extensive sand, silt, and gravel terraces east of Northport and near Marble and Boundary which coincide with the floor of the spillways are proof of local ponded conditions, when the valley was blocked with ice to the west. The way in which the two spillways join in a Y shape and the large amount of erosion that has occurred gives additional proof of a large flow of water away from the Columbia carried by the Aladdin spillway.

Across from Northport the broad valley of Little Sheep Creek enters the Columbia River from Canada. The valley seems too wide for the present flow of water to have developed and doubtless represents another glacial melt water spillway.

Pend d'Oreille County

As described by Large,[2] the Pend d'Oreille Valley in the late glacial epoch contained a sizeable lake named Lake Clark. This lake occupied the valley as far north as Ione. The course of the Clark Fork is post glacial and probably resulted from glacial debris left south of Newport that made the river abandon its old valley which was probably that of the Little Spokane or less likely that of the Spokane itself. Until melting of ice uncovered a lower outlet to the Columbia at Z Canyon or some north-flowing stream ate headwards and tapped the lake, Lake Clark drained out to the Spokane. One glacial spillway existed from the Cuisick meadows through Calispell Lake, the Chain of Lakes, and Elokia Lake, to the Little Spokane Valley. Another has been followed by the line of the Great Northern Railroad from Newport via Scotia to Elk and Little Spokane Valley.

Between Ione and Metaline an abandoned side channel extends east of the Pend d'Oreille valley on a loop that includes Sullivan Lake. The spillway west to the Colville Valley via Little Pend d'Oreille lakes previously discussed probably did not operate very long because the elevation of the divide exceeds 3,000 feet. Water flowed through it only while the Pend d'Oreille Valley was still occupied by a thick glacial lobe.

Eastward in Idaho and western Montana additional glacial melt water channels have been noted but are beyond the confines of this reconnaissance report.

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1 Freeman, O. W., Science 7:61-66, Sept., 1933.
2 Large, Thomas, Pan Am. Geol. 41:259-270, May, 1924.
3 Weaver, C. E., Washington Geol. Survey, Bull. 20:103-106.
4 Jenkins, O. P., Washington Geol. Survey, Bul. 3:29.
5 Pardee, U. S. Geol. Survey, Bul. 677-47.
6 Umpleby, Washington Geol. Survey, Bul. 1:10.

The Building of Men in the Civilian Conservation Corps[1]

By J. M. GLEASON
Capt. Ch. Res. Fort George Wright, Wn.

MAN is the crown of Creation. God gave him dominion over all other created things both on land and in the sea. That which has to do with man's welfare therefore would seem to have a place of preeminence in the general scheme of things on the earth.

Great as have been the accomplishments of the Civilian Conservation Corps as portrayed by the speakers who have preceded me, I hope to be able to convince you that the accomplishments of the Civilian Conservation Corps in the *Building of Men* is the climax of the whole project. None knows better than I the miles of roads that have been built by the men, the forest trails that have been cleared, the lookout towers that have been constructed, the thousands of acres of pine forests purged of blister rust. I have seen the work with my own eyes. And I appreciate fully its real value. Yet the Civilian Conservation Corps declares by its very name that it is not a reforestation scheme, not a road building plan, not a blister rust eradication campaign, primarily, but a man saving, a manhood conserving project, a citizenship building, *Civilian Conservation* Corps.

Man is a three sided being, physical, mental and spiritual. In the building of men the Civilian Conservation Corps has given attention to each of these three phases of man's nature in its proper proportion, in order that he might be a well balanced man. I said man is a *physical* being. And so the Civilian Conservation Corps has looked out for the physical well-being of the men. One of the first needs in building strong men, is wholesome food. And a great force of officers and men have worked to provide food, cook and serve it in appetizing form and in sufficient quantity to give all the most favorable opportunity to develop physically. When you consider the number of men, the wide distribution of the camps, the transportation problems encountered, you will realize that to succeed in this undertaking was no small accomplishment. In Company 258, Captain Hawkinson commanding, 181 men were weighed when enrolled and weighed again prior to the movement toward the East after the summer in the forest. It is shown that the greatest gain in weight was 29 pounds; the greatest loss in weight was 45 pounds. The first was an under-nourished man who needed feeding; the second an over weight man who reduced to normal by dieting and exercise. The average gain of 164 men was 10.88 pounds. Among the men who lost weight the average loss was 9.76 pounds.

In addition to proper food, the men were employed for regular hours at wholesome out-of-door work. Exercise is a great factor in keeping men physically up to par. Medical attendance was provided to take care of the emergencies so that accidents might not be fatal or serious. Preventive measures were taken, frequent sanitary inspections made, hospitalization for sick and injured provided, so

[1] Presented at the annual meeting of the Northwest Scientific Association, Dec. 27-28, 1933, Spokane Washington.

that in every way these young men were probably better cared for physically than they had ever been in their lives.

Second, man is a mental or intellectual being, and the Civilian Conservation Corps was so planned as to provide for the development of this side of man's nature. There was mental discipline in the process of learning to do an hundred and one new tasks. Men learned to distinguish a current bush from a huckleberry, a white pine from a cottonwood. For their leisure hours, magazines and papers were provided. Each camp had its library of books, fiction and history. There were nature books on trees, birds, animals and flowers. The men made use of these books with keen interest. For the Winter months an elaborate program of education has been devised which should make available to the men in the camps the services of trained teachers who would give instruction in Grammar, English, Arithmetic, Spanish, book keeping, or any one of many other subjects that might be selected. We have made partial surveys in our camps to determine what interest there may be in this plan of education. Out of 131 questionnaires that were filled out and returned in one camp, 76 expressed a desire to have instruction and some 43 different subjects were listed. Our State Superintendents of Instruction are cooperating with the Department of Education at Washington, and the teachers are being selected and the work has already begun in some camps.

By all these means it can be seen that the mental side of our men will have its share of attention, and that the winter experience of these men will, if they cooperate, result in preparing them mentally in such a way that they will be better fitted to take their place in Society when they return to their homes.

Then we come to the Spiritual side of a man's nature. And this refers not only to the religious but to the morale. It has reference to the Spirit of the individual, his fitness for the fight of life, his consciousness of his relationship to God and to his fellow men.

To minister to this need of the tree troopers, the welfare forces of the Civilian Conservation Corps conceived a program of games, entertainment and religious service. Athletic equipment was supplied for each camp, for base-ball, basket-ball, boxing, volley ball, and now for the Winter, skis, toboggans and indoor games. Competition between camps develops an *esprit de corps*. Musicians were discovered and programs were given in nearby towns. Return programs came back from the towns. Dances were held which provided social contacts that tended to develop the best in the men. Thus the men from the East came to feel at home in the West.

Then we tried to provide for the religious demand by securing the voluntary services of Protestant, Catholic and Jewish clergymen who made long journeys into the depths of the forest to seek out the camp and call the men aside for a little time in order to tune in with the Father of us all, to get a clearer vision of the standard of life that we all want to follow, and to travel upward and not downward as we proceed on the journey of life. The idea is to help men to find their place and to do their work and to do it well. Just as the tree in growing strong and straight on the mountain side fulfills its destiny, so may a man by being clean and sturdy meet the demands that life lays upon him. It is easy to lift one's eyes to the mountains and to feel that his help comes thence, because God must be high and holy. It

is easy to hear God's voice in the song of the bird and in the running brook. One feels the peace and the strength of the forest and man is built up spiritually.

Thus we see that by a carefully planned and faithfully executed scheme, the Civilian Conservation Corps has built up the men, physically, mentally and spiritually. I saw men come from New York City with a lean and hungry look, a beaten and a haunted look. I saw them ready to turn East again, healthy and hard of flesh. I saw them hopeful and happy, made fit for the battle of life. I saw men come out sour and disloyal and complaining, they had no job, the Government and our industrial system had cheated them. They returned with stouter hearts. Their whole mental attitude had changed. Uncle Sam had played fair with them. I saw minds in which the seeds of disaffection and communism would readily take root, and I saw them again planning to organize a Civilian Conservation Corps Club in New York City, to carry on back there the work of Americanism begun here in the forest camps.

Perhaps I can make the picture of accomplishment clearer if I give you a few concrete examples of the work done by officers with a vision of their mission, officers who labored early and late to make real men. I visited a camp in the St. Joe Forest commanded by Captain Dennis. As we walked toward the mess hall when the supper call was sounded, he told me that it was just a week since he had first occupied the mess hall for meals. "You should have seen them the first time we ate at the tables with the food served in platters instead of mess-kits," he said. "They stampeded into the hall like a pack of hungry wolves, almost fought for the food on the tables, pushed and crowded each other with little more manners than pigs." "Now watch them," said he, and as I sat where I could observe the full length of the table where 100 men were eating it was very evident that they were doing about as well as any group of men would be likely to do if eating alone and not in he presence of ladies. And I said to the Captain: "These men will go back home and teach their mothers and fathers how to eat. They have learned self restraint. They feel that the orderly plan is better. Discipline has begun to have its effect." Then he told me how by patient and constant reminder he had finally induced the men to dispence with their vulgar language. And the atmosphere of the camp was entirely different from that of my first visit, because the stream of vulgar language had been dammed at its source. This again was a tremendous advance in discipline and a real evidence that the process of building men was proceeding step by step in that camp.

Captain Imperatori was in command of Company 1273. "Chaplain," he said, on my first visit to the camp, "I wish you could have heard the story that two boys were telling me this morning. All they have ever known in life is to be beaten and kicked about, half starved and neglected by a step father. It would have wrung your heart." "Captain," said I, "that is your challenge. You play father to those boys this summer. Show them what a real father can be to a boy. Advise them and train them and let them see what they have missed. Make up in some measure for what they have lost." And I say to you, that not only this captain but many other camp commanders did that very thing, and hundreds of young men felt the fatherly influence of big hearted men, an influence that will always be felt.

Chaplain Rein who was assigned to the St. Joe Forest had a C. C. C. driver for his government car. Near the end of the Summer after miles and miles of travel together, the boy broke out one day with these words to the Chaplain. "I wish I could be like you. You do not speak as I speak. I have been in your home and as you talk with your son and your wife your words and conversation are entirely different from anything I have ever known. I have always thought it smart to use rough, vile language. But I see my mistake and I should like to learn to talk and act like you." It was a sign of the boy's awakening. He had come to a realization of something higher and better. As the prodigal in the parable, he came to himself and he arose and came to his father. Who can tell the far reaching result of the boy's new vision of the meaning of life?

These are the evidences that testify to the effectiveness of the means used. These show the process of building men. Figure the accomplishments in dollars and cents. I know the totals will be large. But I will figure the accomplishments in man values and the results will be beyond computation. The dividends from this investment will be returning as long as America lives. We have the second group of men in the camps, perhaps others will follow. Here is a Government building its citizens, its future leaders, building men. And through this process of man building, this accomplishment of the Civilian Conservation Corps when carried on to its logical conclusion, the perpetuity of our American institutions will be assured and the true destiny of our nation attained.

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NORTHWEST SCIENCE

DECEMBER, 1934

Vol. VIII No. 4

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NORTHWEST SCIENCE

Entered as second class matter April 5, 1927, at the Post-Office at Cheney, Washington. Office of Publication, Cheney, Wash.

Published quarterly at a subscription price of $1.00 per year, which includes the membership dues of the Association. Non members $1.00 per year. Vols. I (1927), II (1928), III (1929), IV (1930), V (1931), VI (1932), VII (1933), complete, each $1.25.

Reprints of articles appearing in regular issues will be furnished to the author at the following rates, *provided they are ordered prior to the time of going to press.*

Pages	2	4	8	12
100 copies without cover	$2.50	$3.00	$5.45	$ 5.95
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200 copies without cover	3.25	4.25	5.75	7.90
200 copies with cover		5.50	7.00	9.15
300 copies without cover	3.75	4.50	7.00	10.00
300 copies with cover		6.25	8.75	11.75

Printing of plates extra, at actual cost

NORTHWEST SCIENCE

Vol. VIII DECEMBER, 1934 No. 4

The Association is not responsible, as a body, for the facts and opinions advanced in the papers published by it.

The Occurrence of Spherulites in the Acid Lavas of the Clarno Formation, Oregon[1]

By W. D. WILKINSON

Oregon State College

INTRODUCTION

The Clarno formation, which covers a wide area in northcentral Oregon, is composed of rhyolites, andesites and tuffs. During a detailed investigation of this formation the abundance of spherulites in the rhyolitic flows was a very striking feature. A description of the various types of spherulites and a possible explanation of their mode of origin is offered in this paper.

The first ordinary spherulites may be recognized microscopically in plane polarized light by their brownish colors and spherical shapes, although their boundaries are not sharply marked. Their edges are feathered and light in color for variable distances, but may suddenly change to densen shades. Radiating from the center of each are many trichites, which tend to accentuate the radial character of the spherulites. Where spherulites of this type occur as single individuals, they are almost perfectly spherical, but they occur more commonly as aggregates and then the spherical shape of the individual may be greatly modified or even lost. Where spherulites form in contact there is an apparent tendency for the growth of each to be retarded or to be abnormally directed along a line or axis. There may be a sharp line at the contact or, if no sharp line, the spherical shape may be well preserved. Wherever the spherulites join they form a chain. This arrangement gives the appearance of fine laminations in hand specimens which in part accounts for the observed flow structure in these rocks. The chain appears in the section of the rock cut to the laminations. The spherulites have no apparent arrangement in the sections parallel to the laminations.

Under cross nicols the spherulite appears to be composed of many very fine acicular crystals all radiating from the center. This fibrous character is prominent because of the black cross produced which resembles a uniaxial interference figure. The most perfect spherulitic figures are to be found in the smallest visible spherulites. The largers pherulites (0.5 mm.) show only a figure near the center and then only in certain positions. In aggregates the spherulitic figure is seldom, if ever, symmetrical. Consequently, on rotation of the spherulite, the band of extinction follows a very crooked path and repeats itself every 360°.

These spherulites are surrounded by interlocking crystals of quartz and orthoclase with a granular to felted texture. Occasionally microlites pass

[1] Presented at the Annual meeting of the Northwest Scientific Association, December 27-28, 1933, Spokane, Washington.

through the spherulites. The radial fibers which make up the spherulites are so minute as to be indeterminable by direct microscopic observation, but it is probable that the spherulites are composed of quartz and orthoclase, like the chystalline ingredients of the groundmoss. Although no analysis was made the evidence obtained by staining indicates orthoclase as a constituent of the spherulites.

A second kind of spherulitic growth has been observed in some of the members. These spherulites differ from the ordinary in that they are completely devoid of incisions. Their fibers are clearly defined in plane polarized light. Surrounding each of them is a very narrow brown band with fine acicular crystals. These spherulites occur in cavities, as much as 0.375 mm. in diameter, some of them almost perfect half-circles. The bodies are perfectly transparent in plane polarized light and have an index so nearly that of Canada balsam that a Becke line is not visible.

Under crossed nicols this second kind of spherulite has the most symmetrical shape and the most perfect spherulitic figure of any of those observed in the entire group. The figure as in other spherulites is a symmetrical cross surrounded by concentric interference bands.

The spherulite is composed of acicular quartz crystals arranged in a radial manner about the center. The dark band marking the edge is composed of similar radial quartz but not completely spherical in orientation.

As in the brown spherulites the contact between any two is sharply marked by a dark line. Spherulites approach the symmetry obtained in artificial spherulites described by Morse[2], except that the outer boundaries are terminated by other spherulites growing from other center points.

The third kind of spherulite observed in this particular group is visible only in plane polarized or reflected light. These spherulites are brown in color with deeper shades at the center than at the edges. As in the first kind they contain many trichites which have both a concentric and radial arrangement. Although this spherulite is classed as a different distinct type, there is no reason to believe that its mode of origin or general structure is different except that the body is opaque between crossed nicols. Along the thinner edge of the slide it is just possible to discern the trace of a spherulitic figure, and the difference, then, is probably in the degree of coloring.

Origin of Spherulites

The common or ordinary spherulite has a mode of origin slightly different from the second. Its growth started at the beginning of crystallization of the magma. In order to crystallize, the magma had to reach a point of supersaturation, provided it was not seeded[3](. Once saturation had been attained, crystallization should have begun, but it is not certain as to what course the crystallization should have taken. If cooling were relatively slow there should have been a tendency to form euhedral or subhedral crystals. If cooling were rapid the tendency would have been to form glass with a few trichites, microlites, and accompanying spherulites.

From work on artificial spherulites it has been found that the most favorable conditions are those in which there are no convection currents and the system is supersaturated. Excellent artificial spherulitic growth has been observed by the writer in microchemical work. The condition most favorable for the growth on the slide was rapid cooling, which brought

2 Morse, H. W., Warren, C. K., and Donnay, J. D. H.—Artificial spherulites and related aggregates—Amer. Hour. Sci., 5th Ser., Vol. 23, No. 137, pp. 431-439.

3 Harker, Alfred—Natural History of Igneous Rocks, 1917, p. 207.

about a state of supersaturation. As soon as supersaturation point was reached, innumerable centers of crystallization formed. This was followed by a second period when long crystals developed radially from these centers. With these points in mind one may turn to a consideration of the magma. At the time of its extrusion it had a temperature at least 870°, possibly higher, for trilymite is present in some sections. With the extrusion the lava began to lose heat rapidly. With loss of heat there must have been an increase in the viscosity and a supersaturated condition must have been attained and suddenly passed. Numerous centers of crystalliation must then have appeared and rapid crystalliation must have taken place until a condition of saturation hed evolved. It must have been during this period of rapid cooling and crystallization that the spherulites were formed.

The mechanics of growth are apparently identical with those observed in various microchemical products. Centers of crystallization must suddenly appear, and, immediately following with only slight cooling, accicular crystals must radiate from each of these centers. The crystals would tend to form along the line of greatest molecular attraction, taking up the molecules from the surrounding solution. This would determine the direction of growth. Once elongation had begun in any one direction, growth in that direction must have been much more rapid than in any lateral direction. The most rapid growth would occur at the point of greatest saturation. As the crystal grew, the concentration would be reduced at the end, but as the end would always be in contact with a slightly more concentrated solution than that of the side; the growth therefore would tend to elongate rather than widen the crystal.

4 Op. cit., pp. 431-439.
5 Op. cit., pp. 431-639.

So far, only a single crystal has been considered. Actually there are thousands of fibrous crystals forming almost simultaneously from the same point. In that case the zone of greatest concentration would be fixed by a circle with the seed crystal as the center. Normal growth of this kind must necessarily be radial to this ever widening circle of greatest concentration.

The third stage of crystallization should be reached after the spherulites had reduced the concentration of the liquid magma to a point of saturation. Then normal euhedral crystals should begin to form in the surounding magma. Eventually, there would be complete crystallization.

It has been observed that the lack of convection currents in a gel favors the formation of spherulites (Morse)[5]. High viscosity in a magma would prevent convection currents, and if the above hypothesis is true, the less convection the more favorable would be the condition for formation of spherulites. Convection currents would tend to change the concentration mechanically. If these currents were more rapid than the rate of crystal growth the spherulitic structure would necessarily be destroyed. In a magma with a high viscosity, flow and convection must be much slower than the rate of growth of spherulitic crystals.

The slow movement of a flow has little effect upon the formation of the spherulites, because excellent spherulites may be formed even though flow has taken place along the boundary. In one example the flow line was observed to pass through the spherulite, which resulted in a slight distortion of the fibers. It is probable that the distortion which results in a wavy cross between crossed nicols is due to the very sluggish motion of the viscous lava. This motion produces variation in the conditions favorable to crystallization. Once the spherulite has developed it should react toward the

motion of the magma the same as any crystal. It might be moved or it might act as an obstruction to slow motion and cause later flow lines to diverge and move around it.

The second kind of spherulite would have the same mode of crystal growth, but that growth would take place under different circumstances. This kind developed in a cavity. The suggested explanation follows that of Cross[6], who believes that the first stage in the development is the formation of a globule of collodial silica, which acts as a nucleus for later crystallization. Silica would fill the cavity as a gel and the crystalliation as already described would follow later.

Various theories have been presented in addition to the one suggested by Cross. Iddings[7], thought that spherulites were influenced by absorbed water or absorbed water vapor, which rendered the magma more mobile along particular zones. Work on artificial spherulites indicate that this condition is not favorable to the formation of spherulites, although it may be an important factor in the growth of crystals. Mobility does not favor the formation of artificial spherulites.

Rosenbush[8], believed the phenomena the result of tensile stresses set up in contracting concentric shells in an amorphous material. However, in the spherulites of the Clarno rhyolites the concentric layers are visible only in plane polarized light and appear to be due to a difference in color only and not to any other difference in layers of acicular crystals. This concentric banded appearance is lacking between crossed crystals.

None of the hypothesis offered by Cross, Iddings and Rosenbusch on the origin of spherulites seem completely satisfactory. Each postulates special conditions. On the other hand, the writer's explanation postulates no special conditions other than those supposed to exist in an acid magma. The origin of these as suggested earlier is supported by the work of other investigators on artificial spherulites including microchemical preparations.

At least two kinds of spherulites are present in the Clarno rhyolites. Of these the first has been divided into two subgroups, one which is transparent and almost colorless; the other brown and almost completely opaque. The second kind occurs in cavities and is secondary. The first is primary and must be considered a part of the original rock.

6 Cross, Whitman—Constitution and Origin of Sperulites in Eruptive Rocks., Bull Phil Soc., Wash., XX-1891, pp. 411-444.

7 Iddings, J. P.—Obsidian Cliff, Yellowstone National Park, U. S. G. S., VII Am. Report 1888, 264-72; Idem—The nature and origin of lithophysical and laminations of acid lavas, Am. Journ. Sci. XXXIII, 1887, 36-45.

8 Johannsen, Albert—Descriptive Petrography of Igneous Rocks, Vol. 1, pp. 9-17-20, 1931.

Historical Sketch of the Northwest Scientific Association

By O. W. FREEMAN

Secretary-Treasurer

The Northwest Scientific Association was organized February 24, 1923. L. K. Armstrong of Spokane was chairman of the organiation meeting. Superintendent O. C. Pratt and Thomas Large, both of Spokane, were enthusiastic supporters of the organization along with men from the University of Idaho, Washington State College, Spokane University, Cheney Normal and other institutions. The first president was M. F. Angell of the University of Idaho and the secretary was F. D. Heald of Washington State College.

The first meeting was held in April, 1923, in connection with that of the Inland Empire Teachers' Association. It was agreed that section meetings would be arranged in accordance with titles offered. Meetings continued to be held in April during 1924 and 1925. Beginning with 1926 the annual program and business meeting has been held at the Davenport Hotel in Spokane for two days during the Christmas holidays.

In 1927 J. W. Hungate of Cheney was elected secretary-treasurer, serving six years until 1932. The present secretary is O. W. Freeman of Cheney Normal.

Past presidents have been:

1924 M. F. Angel, University of Idaho
1925 M. A. Brannon, University of Montana
1926 C. H. Clapp, University of Montana
1927 L. K. Armstrong, Spokane, Washington
1928 E. A. Bryan, Washington State College
1929 J. A. Kostalek, University of Idaho
1930 F. A. Thomson, State School of Mines, Butte, Montana
1931 E. O. Holland, Washington State College
1932 I. C. Crawford, University of Idaho
1933 H. R. Flint, Forest Service, Missoula, Montana
1934 Thomas Large, Lewis and Clark High School, Spokane, Washington.

In 1927 the society began the publication of a quarterly "Northwest Science," in which papers presented at the annual meetings have regularly appeared. Due to decline of advertising patronage the organization has lost money on its publication the last three years, but fortunately has a reserve fund from previous years that should be sufficient to carry the society through the balance of the depression. The first editor was Dr. F. D. Heald, who served the association faithfully for two years. In 1929, L. K. Armstrong was appointed editor and served for a year. The present editor is E. E. Hubert of the University of Idaho, who has served since 1930. Two special geology numbers of "Northwest Science" have been issued. Many outstanding papers have appeared from other sections, especially that of forestry.

The membership has kept up well and totals approximately 325 at present. Most of these are from the four northwestern states with a sprinkling of members from all over the country. Annual dues are $1.00 and include subscription to "Northwest Science." Besides individual membership there are seven institutions that donate from

$10.00 to $25.00 annually to help support the Northwest Scientific Association. These are: University of Idaho, State College of Washington, State School of Mines, Butte, Montana, Whitworth College, and the State Normal School of Cheney, Ellensburg, and Bellingham.

Section programs are presented at the annual meetings as follows:

Botany-Zoology, Chemistry-Physics-Mathematics, Education, Engineering, Forestry, Geology-Geography, Medicine-Surgery, Social Science.

May 7, 1928, the Northwest Scientific Association was incorporated under the laws of Washington as a non-profit organization engaged in reseach work.

The Northwest Scientific Association was incorporated largely with the intention of exerting more influence upon scientific research in the Northwest. It is hoped that funds will sometime be donated to the society that will enable it to help finance needed research problems and publish the results of research. A committee headed by the late J. E. Kirkwood of the University of Montana worked out a complete plan for the society to give such aid to research but because, unfortunately, no funds have been donated, nothing definite has been accomplished. A committee is now engaged in a survey of research needs in the Northwest that will report at the annual meeting in December, 1934. It is hoped that this will lead to a furtherance of the cause of scientific research and that a definite plan may attract donations from those interested in advancing this cause.

Translocation of Solutes in Plants[1]

By HARRY F. CLEMENTS

Washington State College

The migrations of the various substances in plants have until recently received little attention from investigators. The reasons behind this are difficult of determination, but the fact remains that until Dixon of Trinity College and Curtis of Cornell University became interested some fifteen years ago essentially nothing was known of the process beyond the vague conjectures of Malpighi in the late seventeenth century, and of Hales in the beginning of the next century. The general idea which prevailed was that water with its dissolved salts moved upward in the wood while the organic foods synthesized in the leaves moved downward in the bark. The very nature of the respective findings of Dixon and Curtis opened the problem so vigorously that since their first papers appeared a great deal has been accomplished toward understanding the various movements of plant solutes. Thus, Dixon as a result of certain dye experiments concluded that not only did the inorganic salts move upward in the xylem but that the organic materials from above moved downward in the xylem, as well. Curtis, on the other hand, using girdling experiments concluded that the movement of the organic as well as that of the inorganic salts took place for the most part in phloem tissue. Thus, with these two totally contrasting views the problem became a pertinent one. Within the last fifteen years many contributions have been made, and as is usually the case, our ignorance of the gross aspects, to say nothing of the details of the process, has been increasingly appalling.

I shall during the course of this paper attempt to show what advance has been made in this fertile field of research and at the same time attempt to point out the various problems as they are today. The paper is divided into several topics: The tissues concerned in the movement of inorganic materials; The lateral transfer of inorganic materials from one side of the plant to the other; The tissues concerned in the movement of organic materials; The movement of the various organic materials including carbohydrates, nitrogen compounds, and fats; The mechanism of phloem movement.

THE TISSUES INVOLVED IN THE MOVEMENT OF INORGANIC SOLUTES

Dixon and Mason (24) presented evidence that the movement of soil solutes takes place essentially in xylem tissue. Curtis (17, 18, 19, 20), on the other hand, contended that this movement takes place in the phloem. In arriving at this conclusion, Curtis used two types of procedure: girdling experiments in which the continuity of the bark was broken by removing a band of the tissue, and chilling experiments in which various parts of the plant were chilled and the results of such treatment were interpreted on the assumption that only living cells would be affected. Clements (10) has pointed to the error of the first procedure. The conclusion that a girdle interferes with the upward movement of soil solutes is correct, but the further conclusion that this interference indicates a movement in the phloem is logically unre-

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1 Contribution No. 37 from the Botany Department of the State College of Washington. Presented before the 1933 meeting of the Northwest Scientific Association.

lated to the first conclusion and to the data which Curtis offers in support of these conclusions. Clements has shown that a girdle interferes with the upward movement of materials only in so far as it interferes with the upward movement of water. The reason for the different responses of various plants to girdling can be explained on the basis of their respective stem anatomies. A girdle may severely handicap the movement of water with its contained salts, as in the case of *Prunus americana,* because of the effect of the girdle on the acting conducting elements of the xylem; whereas, a girdle around the stem of the grape has no effect on water movement and hence no effect on the upward movement of salts. Some of the girdled stems of the grape increased in salt content above the girdle as much as 220 times the amount present at the time the girdle was made.

The second procedure which Curtis (21) followed was likewise faulty. He assumed that when a petiole is chilled only the processes taking place within living cells are affected. This obviously is not the case. The rate of water movement through the non-living tracheal system is, among other things, dependent on the resistance to such movement. Assuming the water to be distilled water, a drop of 25°C. in temperature acting on this water would nearly double the viscosity of the water and hence would greatly increase the resistance to its flow through the small tracheal capillaries. The xylem sap, however, is not pure water, but according to Malhotra (31) and Anderssen (1) it contains salts, sugars, soluble nitrogen, and organic acids. This in itself would tend to increase the resistance to flow at ordinary temperatures as well as increase the degree of viscosity change following a drop in temperature. Hence, Curtis' conclusion that chilling the petiole slows up the salt flow is not surprising but it certainly does not indicate that the movement of salts is taking place in phloem tissue.

It appears, therefore, that the upward movement of soil solutes takes place chiefly in the transpiration stream. The advantages to the plant of such movement have been pointed out previously (12).

But this does not complete the activity of salts in the plant. After these salts have reached the leaf, they may be moved again to other parts of the plant. Colby (13) studied the effects of starvation on the redistribution of mineral nutrients in French prune trees and found that a plant would grow in distilled water for two years. Under such conditions the minerals would move from one place to another for growth. Burke and Morris (7) report that the leaves and new growth of apple trees secured only parts of the various salts from the soil each year—the remainder comes from other portions of the plant. Mason and Maskell (39) show that there is considerable movement of phosphorus, potassium, and other ash elements, except iron and calicum downward through phloem tissue. They further report that these salts travel over gradients much as carbohydrates do. However, it appears that salts do not necessarily move to the leaves before they can reach the bark. Unquestionably much of this movement takes place directly from the xylem via the rays. Dowding (26) found potassium relatively concentrated about the pits of the tracheids as well as in the rays of *Picea canadensis.* It appears, then, that this movement of salts from young leaves to old, from leaf to stem, and from stem to root takes place largely in phloem tissue. How much of the movement from old leaves to young, and from leaves and stem to growing points takes place in phloem and how much in xylem tissue has not been determined.

The possibility of a downward movement in the xylem has received some attention. It has been shown repeatedly that there is a removal of salts as well as food materials from leaves prior to their fall from the plant. It is not very likely that such movement takes place in the xylem since water appears to be moving through it into the mesophyll. It is more likely that whatever backward movement of this type there is, takes place through phloem and other tissues. That there can be a downward movement in the xylem under certain environmental conditions seems to have been demonstrated. Gray (29) has shown that in certain regions of California where plants are growing in very dry soils and where fogs roll over the land from the sea that there is considerable foliar absorption and a backward movement of it presumably through the xylem. When herbicides were applied under such conditions they moved backward with this water. Further, Brazeale (6) has shown that there may be a movement of water from roots growing in moist soil to roots in soils whose moisture content is below the wilting point. This is so marked that the dry soil increases its moisture content at the expense of the plant. This would imply a backward movement of water with its solutes in the xylem.

To summarize, then, it appears that the upward movement of soil materials takes place in the xylem; that the downward movement of salts from leaves takes place through the phloem; that the bark may obtain its salts from the leaves or directly from the xylem via the secondary rays; that there may be a movement of the salts in the bark through the rays into the xylem and up; that under certain environmental conditions there may be a backward movement of water with its salts in the xylem.

The Lateral Transfer of Inorganic Materials from One Side of the Plant to the Other

The movement of solutes from one side of the plant to the other has received some attention from investigators. Insofar as herbacious plants are concerned, that is, plants in which the primary vascular system is more important than the secondary conductive system, it appears that the movement of ions upward ends in a more or less uniform distribution throughout the plant. The reason for this is obvious since the primary strands of xylem anastomose and separate at least at the nodes with some of the branches leading into the leaves, some straight up the stem, and some around the stem where they anastomose again, and so on. But when solutes are moving up secondary xylem tissue far removed from the primary system, the evidence indicates that minerals absorbed by the root system on one side are conducted to leaves which are in vascular contact with the absorbing root. There may be some tangential diffusion taking place but this would probably be too slow for its detection. Auchter (2) approached this problem by using trees which had been undernourished so far as nitrates are concerned. He removed one-half the root system and supplied nitrogen fertilizers to the other. He found only the half of the tree with the root system intact responded to the fertilizer. He found, however, that the other half continued to get water which obviously had to move laterally. It is difficult therefore, to understand how the salts which are carried upward with the water were filtered out in the lateral movement of water across the radial walls of the conducting tubes. He found ash constituents unsatisfactory criteria for such studies, possibly indicating that they had actually moved with the water. How the nitrates moved up only to one side might be explained on

the basis that, as Thomas (49) has shown, they lose their identity as nitrates in the fine roots of the tree and therefore move as amino acids. Whether the radial walls of the xylem are less permeable to these acids or whether these acids move up the phloem has not been determined. Bodenburg (5) by using willow cuttings concluded that there was no lateral transfer of lithium nitrate from the young root on one side of the cutting to the leaf on the other side of the cutting. Inasmuch as the leaf wilted and had to have water furnished it from a notch underneath it indicates that the leaf was incapable of drawing water across the inactive xylem. It should be possible to draw water across the old wood if the cut ends of the cutting were effectively sealed, but there would be no point to it. Such experiments merely show the tremendous resistance of plants to mutilation but so far as depicting the process of whole plants is concerned, they show nothing.

To summarize, plants which have essentially only a primary conducting system receive ions from either side of the root system. Trees which depend entirely on the secondary tissue for conduction when unmutilated do not have much if any lateral transfer of ions. To be sure, there can be a movement through the rays from the inside to the outside of the plants but essentially no transfer from one side to the other, except what little might diffuse tangentially through the radial walls of the conducting elements.

The Tissues Concerned With the Movement of Organic Materials in Plants

Dixon and Mason (24) attempted to demonstrate that the downward movement of organic materials takes place in the xylem. They did this by removing a portion of a potato plant and placing a dye over the wound. They found that the dye moved downward in the xylem and concluded that the downward movement of organic materials took place in certain xylem strands while the upward movement of water and salts took place in other strands of the xylem. This conclusion was soon discredited, however, for it was shown that this movement was due not to the regular function of an uninjured plant but to a backward suction caused by an inadequate water supply in the xylem. When the plant was saturated this downward movement no longer occurred. Mason and Maskell (37) using girdling methods discovered that the downward movement of carbohydrates was interrupted whereas that of the dye was not. Curtis had found that girdling interrupted the downward movement of carbohydrates. Bennett (4) likewise had demonstrated this with the various brambles. In fact, it is quite generally accepted that downward movement of carbohydrates takes place in the phloem. Mason and Maskell (37-40) by means of tissue dissection and subsequent analysis have shown the above tubes to be the channels through which this transport took place. The structure of the sieve tubes together with their position in storage organs and leaves would, of course, indicate this. However, it is probable that under certain circumstances the pith as well as the cortex may serve as food conducting channels. Barton-Wright and M'Bain (3) have shown that in the potato plants whose internal as well as external phloem strands have been destroyed by virus, carbohydrate movement continued, although at a reduced rate. But so far as roots and stems and petioles are concerned, it seems reasonably certain that the sieve tubes of the phloem are responsible for the movement downward.

The movement of the organic substances upward is less well established. Many experiments have indicated the upward movement is like-

wise in the phloem. Curtis (18-20) has shown that girdling a very young shoot of Philadelphus causes its death. Mason and Maskell (37-40) demonstrated this movement by defoliating or darkening leaves and found a reversal of the carbohyrate gradient in the phloem. Bennett (4) found that when he defoliated a raspberry shoot and girdled it, growth of new leaves did not take place, but when he left a narrow bridge of bark in the girdle growth took place at once. It follows that the movement of carbohydratse upward in the phloem is common to many plants. Perhaps in these plants the storage is chiefly in the bark tissue. Of course, in annuals, there probably is no storage except in the fruit or special storage organs. However, in trees and plants in general where foods are stored in xylem tissues, it seems faily well demonstrated that the xylem conducts at least some of the sugars and nitrogen compounds upwards. Engard, one of my associates, has been collecting information regarding the spring movement of sap in the maple. He finds very large quantities of sugars, hexoses as well as disaccharides, moving through xylem tissue. Double girdles did not in any way interfere with this movement. Yet, Curtis working with the sugar maple found that a double girdle prevented the complete disappearance of starch from the xylem between the girdles. Whether or not this starch ever disappears completely, he did not report. It is, of course, common knowledge in tapping for maple sap that the tap is made into the xylem and that one can watch the actual flow of liquid coming from the wood. In other words, it appears more likely that in plants in which a considerable portion of the stored food is laid down in the rays and other living cells of the xylem, that at least some of the sugar if not a goodly portion of it is moved upward through the xylem. Gardner (28) has found that the tracheae are at least capable of conducting sugars and amino acids upward. Malhotra (31) and Andersen (1) reports sugars and nitrogen compounds in the tracheal sap expressions, but whether this is from injured tissue cannot be determined. Just how much xylem movement of organic material there is in uninjured plants is, of course, a matter for further work. Numerous experiments have shown that twig growth and blossoming in the apple is made possible by food materials near at hand. Girdling apple twigs in spring within a short distance of the blossom does not seem to interfere with the development of the flower. It appears that there is at least some movement of carbohyrates and possibly amino acids upwards through xylem tissue in the spring. It also appears that as soon as these leaves are developed to a size where they can grow on their own synthesized foods, that this upward movement ceases. The actual amounts of such upward movement in the xylem and phloem have not been determined. Also, in those plants with storage organs near the tip of the plant, the amount of movement respectively in the xylem and phloem has not been determined.

In seeds, the movement of materials which will be deposited for permanent storage has not been determined. At any rate whether this material moves through xylem or phloem the fact remains that once the food enters the endosperm there is no phloem or xylem tissue differentiated. In other words, the movement there is through parenchymatous tissue. Of course, the extent of such movement is limited because of the relatively small size of seeds, generally. In the large sporangia of plants such as Psilotum there appears the development of a conducting tissue from sporogenous tissue. This tissue is not made up of sieve tubes or tracheae but rather of somewhat elong-

ate parenchymatous cells. Whether this tissue has become specialized because of the movement of water or foods or both through it because of its central position or not doesn't disturb the fact that the movement of these substances at least takes place through tissues other than specialized cells.

In other words, the movement of foods over long distances generally takes place downward through stems and roots in the sieve tubes. The upward movement perhaps is characteristic of the plant but appears to be divided between the xylem and the phloem. When phloem tissue is destroyed, it appears probable that the pith and cortex serves as tissue through which some of the movement may take place.

The Movement of Carbohydrates in Plants

Since carbohydrates are synthesized only in green parts of the plant and stored usually in fairly definite places, we at least have the source of supply and place of deposit fairly well established. It will be well now to consider the form in which carbohydrates usually move. Normally occurring in leaves and other photosynthetic tissue are hexoses, disaccharides, occasionally some trisaccharides, dextrins, starches, hemi-celluloses and the glycosides. The hemi-celluloses and the insoluble starches may be eliminated from consideration since they are insoluble reserves which could not diffuse from cell to cell to the phloem. In a previous paper (9), it has been shown that dextrins and the soluble starches show no fluctuations in the petioles of several plants. Thus, we have only to consider the pentoses, hexoses, disaccharides, trisaccharides, and the water soluble glycosides. The last two cannot be discussed at present because of a lack of data. Of the simple sugars, I shall discuss only the two hexose sugars, glucose and fructose. Mannose (11) has been shown to be absent quite generally from photosynthetic tissue as has galactose (30). The pentoses, xylose and arabinose have been found in plants especially under xeric conditions, but so far as I am aware no work has been done dealing with their translocation. Of the disaccharides only sucrose will be considered in this connection since the presence of maltose in leaves of plants has been seriously disputed (23).

The forms then which I shall consider are the two hexoses glucose and fructose, and the disaccharide sucrose. Davis, Daish, and Sawyer (23) working with mangold leaves concluded that sucrose was the primary sugar of synthesis and that on entering the veins it changed to hexoses as is evidenced by the fact that in the laminae the sucrose to hexose ratio is high whereas in the vein it is the reverse. Strakosch (48) working with the sugar mangold found hexoses much more abundant in the mesophyll than sucrose but concluded that simple sugars are converted to sucrose on entering the vein. Mason and Maskell (37) in 1928 state that the mesophyll cells are relatively impermeable to sucrose, and in 1933, Phyllis and Mason (44) state that sucrose is the chief form in which carbohydrates move from the assimilating cell to the phloem of the bundle ends and also longitudinally through the phloem. Perhaps such a diversity as well as inconsistency of opinion is difficult to understand. Clements (9) offers numerous data collected from the leaves and petioles of *Helianthus annuus, Soja max,* and *Solanum tuberosum.* Under the field conditions prevailing through two successive seasons, he found that invariably sucrose was much less abundant in the petioles than the simple sugars and that in many instances where translocation was going on sucrose was absent from the petiole. In fact, it seemed that when sucrose was absent from the

laminae, it soon disappeared from the petiole. This, of course, suggests that there is no transition from the sugar of photosynthesis to the sugar of translocation, but rather whatever sugars that are found in the mesophyll will also be found in the vein. Quite a difference was noted between old and young leaves. With young leaves the simple sugar content of the petioles varied from 0.9 to 1.4% (green basis) while the sucrose content varied from 0.0 to 0.3%. In the petioles the simple sugars varied from 2.4 to 4.8% while the sucrose content was practically constant at about 0.3%. With the soy bean the young petioles contained simple sugars to the extent of 0.2% to 0.3%, and sucrose from 0.0 to 0.2%, while the old leaves contained 0.9 to 1.6 and 0.3 to 0.4% respectively. The potato showed similar relations. In fact, in the potato tubers prior to starch formation, sucrose may act as a storage form. I found young tubers to contain as much as 16% of their dry weight in sucrose. To be sure, any macrochemical data must be used with reservation regarding this movement. Yet, it would appear as logical, if logic may be used, that the smaller and simpler molecules of hexoses could move more rapidly than sucrose. On the other hand, sucrose is presumably smaller than two molecules of hexoses. However, the data which I have collected indicate that the same enzymatic equilibrium is set up in the petioles as in the laminae; namely, that when simple sugars appear in excessive amounts that an inversion to sucrose might be expected and that under such conditions sucrose as well as the hexoses are the forms in which translocation of carbohydrates takes place. Mason and Maskell (32-40) studied the movement of carbohydrates in the cotton plants and their findings will be briefly reviewed here. As the carbohydrates are synthesized in the leaves they begin their migration to the stem at once. During the day, because of higher temperatures and perhaps greater concentrations, the rate of transport is about four times faster than at night. The accumulation of sugars in the leaf is reflected later in fluctuations in the bark. The movement downward takes place along well defined gradients in sugar concentration. In these gradients, the concentration of hexose sugars remains fairly constant while the fluctuations can be accounted for by the fluctuation of sucrose. That the movement downward is comparatively easy is indicated by the fact that the lateral gradients from the sieve tubes to the bark are 500 times steeper than the longitudinal gradients in the sieve tube. Further, the rate of longitudinal movement in the sieve tube is closely correlated with the observed gradient in the bark and is some 40,000 times faster than can be expected by diffusion. When the stem is ringed, the carbohydrates accumulate above the ring in both bark and xylem and yet there is no effect on the transpiration stream. If the girdle is not complete, the total movement through this band is less than the total movement before the ringing, but a considerable increase in the rate of flow is found due to a steepening of the gradient through the slit.

The Movement of Nitrogen Compounds

The movement of nitrogen compounds in plants is more of a perplexing problem in plants than the movement of carbohydrates. The reasons are many but perhaps the chief one for this difficulty is the fact that the place of assimilation of the inorganic into the organic nitrogen is not as localized as the synethesis of carbohydrates. Thomas (49) finds in Pyrus Malus that synthesis of nitrates into amino acids takes place in the fine roots. Nightingale and Scher-

merhorn (43) report that nitrates are changed in the root of the asparagus plant before any part of the plant has emerged. Eckerson (27) reports the assimilation of nitrates in the tomato plant to take place in scattered areas of cortical tissue of the petioles distributed in the cortex of the stem as well as in the petioles, in leaf cells, cells near the stem tip and above the nodes. In some data not yet published, I found nitrates accumulating and then disappearing in the head of the sunflower and the fruit of the soy bean. Chibnall (8) and Maskell and Mason (32-36) report some diurnal changes in the leaves of plants. It seems, according to Eckerson (27), that whenever there is a supply of carbohydrates, phosphate ions, nitrates, reducase, and a proper pH that assimilation takes place. It appears that this set of conditions may be found in almost any part of the plant. Whether this is exactly the same in any given plant at two different times is not too well established. It is possible that a goodly proportion of the assimilation of nitrates especially in annual plants may take place in or at least near the place where the nitrogen is ultimately to be used, and that there is little translocation of the finished products. Nitrates, of course, move to these places as inorganic ions. It is possible that the partial assimilation of the nitrate to ammonium nitrogen may take place in one region followed by the translocation of the ammonium compound to another region where the last stages of assimilation are accomplished. However, in plants such as Pyrus Malus where at least much of the assimilation takes place in the fine roots (evidently the first contact nitrates made with the other essentials of the process) that there is a movement of organic nitrogen. Maskell and Mason conclude that all forms of nitrogen, including protein nitrogen, may be expected to take part in the longitudinal movement in the phloem, although it is probable that the amino acids and the acetamide, asparagine are the more important forms. Nightingale suggests asparagine as a translocatory form. Very probably the cell to cell movement is accomplished by these simpler forms. However, once in the sieve tube, it should be possible for more complex forms to move.

In the cotton plant, it appears that much of the assimilation takes place in the leaves. Strangely enough, assimilated nitrogen moves down the sieve tube against a total nitrogen gradient. However, Maskell and Mason explained this when they found that the total nitrogren gradient contained a great deal of immobile nitrogen and that when only the crystalloidal nitrogen was considered that the gradient was positive. There appeared to be an equilibrium existing between the mobile and immobile nitrogen for under condition of varying pH, desiccation, sugar concentration it could be changed without changing the total nitrogen content. When the downward movement of nitrogen was stopped, a marked negative gradient persisted, but when the downward movement of carbohydrates was stopped the gradient disappeared. Thus, the negative nitrogen gradient appears to be made up of non-motile nitrogen, for, when the movement of nitrogen is reversed, the negative gradient is steepened. In other words, with the static gradient remaining, when a reversed dynamic gradient is superimposed on the static the total nitrogen gradient is markedly steepened. Perhaps this static gradient of immobile nitrogen is an important part of the translocation machinery for carbohydrates as well as nitrogen.

To summarize, the movement of nitrates and ammonium salts constitutes a large portion of the actual transfer of nitrogen from one part of

the plant to another. The synthesis of these forms in storage organs requires little transfer of organic nitrogen. The movement of organic nitrogen from places of synthesis to places of utilization, from places of synthesis to places of storage, or the movement of nitrogen from places of utilization to new places of utilization probably takes place in the form of the amino acids, asparagine, and other simple nitrogen forms on a gradient pattern, although much faster than can be explained by physical diffusion.

The Movement of Fats and Oils

Studies of the movement of fats and oils have not been numerous. Sachs (46) was of the opinion that fats could move through cell walls but that mostly they are transformed into carbohydrates and moved in that form. Schmidt (47) also contributed to the idea when he studied many plants in regard to their ability to move oils. Rhine (45) in 1926, however, found plants incapable of transporting fats and oils. He found that the greater the viscosity of the oil, the slower was its movement. He found further that desiccated cells could take in oil from the intercellular spaces, but when saturated with water they would allow neither the absorption of oil nor the rise over their surfaces. In other words, whatever transport takes place follows after the oils and fats are changed to carbohydrates and perhaps fatty acids or soaps. As these reach new tissues, they are resynthesized. It is possible that whatever oils are formed in phloem sieve tubes could be moved along the tubes particularly if they are in a fine state of dispersion.

The Mechanism of Translocation

Perhaps the largest single problem in this field is to determine the mechanism which is employed in moving the various compounds from one part of the plant to the other. Until recently, it has been assumed by botanists in general that this movement is one of physical diffusion. That is, the sugars diffuse from the leaves, the source, to the place of utilization or storage, the sink, where they are destroyed or changed into other substances and the movement is thus continued. However, there are several serious objections to this concept. In the first place, I have found with the sunflower that while the leaves are the source of carbohydrates, their sugar concentration will be from one-twentieth to one-tenth the sugar concentration of the stem into which the sugars are moving. In this plant the pith is very high in sugar content until after head formation. Here, obviously sugars are moving from points of low concentration to points of high concentration. This is the reverse of the expected if diffusion is the mechanism of transfer. Another serious objection to this interpretation is the matter of speed. Dixon and Mason calculated that if the carbohydrate of the potato tuber entered through the phloem as a ten per cent solution it would be necessary for it to move at the rate of 50 cm. per hour. Mason and Maskell calculate the rate of carbohydrate movement to be 40,000 times that in a two per cent solution of water and is identical with the diffusion constant for molecules the size of sucrose moving through air. In a previous paper (9), I have shown how nine per cent of the dry weight of a sunflower leaf may move from the lamina and petiole in the course of an hour. One can see at once the inadequacy of physical diffusion to explain the speed necessary. The suggestion was made that the rotation movement of the content of the seive tubes would augment diffusion in speeding up the process. However, it appears that only the young seive tubes possess this movement. Further, Crafts (16) has shown that the rate of this movement is only 1.8 cm. per hour in young sieve tubes of the potato whereas a rate of

some 56.88 cm. per hour would be necessary.

The idea of physical diffusion has one very distinct advantage which another interpretation does not have. It would be possible to have a movement of two substances in opposite directions at the same time. Although this two directional movement has never been demonstrated, it is more than likely where we have, for example, synthesis of carbohydrates in leaves with their downward movement to places of nitrogen synthesis then with the upward movement of the synthesized nitrogen. Further, diffusion would also allow for a differential rate of movement of two different substances in the same direction, a phenomenon which Mason and Maskell have demonstrated.

A second suggestion is that of Münch (42). He suggests that the protoplast of sieve tubes is highly permeable to mass movement of water and that through the sieve tubes and the plasmodesmal connections there is a mass movement of solution. This would mean that in the potato, for example, a solution of sugar moved into the tuber where the sugar would be dropped and the water would find its way into the xylem and back up the plant. Of course, the only difficulty with this idea is that such a movement has never been demonstrated. However, there are several difficulties which I think will make impossible the realization of this interpretation. In the first place this idea could not allow for a two directional movement taking place simultaneously. In the second place the mechanism for the movement has not been demonstrated. Dixon (28) reports that the osmotic pressure of sieve tube exudate is higher when the sap is collected higher on the stem than when it is collected at lower levels and hence would make possible the flow through these tubes since water would move into these tubes at the higher levels and be emptied at the lower levels. He feels he can explain by this means the findings of Mason and Maskell. However, he explains only certain of their findings which incidentally makes his findings redundant for they are what one might expect. They have demonstrated a high sugar gradient in the sieve tubes at the upper part of the plant which, of course, makes possible Dixon's high osmotic pressure. But their findings that the carbohydrates load and the nitrogen load in the phloem move at different actual rates of speed cannot be reconciled with Dixon's explanation. Certainly, if there is a mass flow of the sieve tubes, the two components would move at the same rates even though there may be a greater load of the one than of the other. Crafts (14-15) has shown that there is an exudate when the phloem of squash is cut. This movement stops after a time presumably because of plugging, but let us suppose that it doesn't stop. This still would not indicate a mass movement in the uninjured tubes for it is rather common knowledge that the osmotic pressure of the phloem is higher than that of the surrounding tissues. As a result the sieve tubes are under a considerable hydrostatic pressure. Now if the sieve tubes are broken by an incision it is quite obvious that an exudate would form. It is also obvious that were plugging prevented the flow would continue, for once the hydrostatic pressure is released more would be formed as a result of osmosis taking place from adjoining tissues and making a continuous flow impossible It may be pertinent to ask why does plugging take place if the flow is a normal process in the plant? It may of course, be due to the action of air on this exudate but it likewise may be due to the unnatural flow forcing sieve tube protoplasm into the sieve

plates causing clogging. But no matter what the outcome of such experiments they still fail to demonstrate what happens in the uninjured sieve tube system.

A third criticism of this idea is that it is difficult to conceive of a mass flow in the sieve tubes without a marked effect on the sieve tubes structure. Crafts (14-15) has shown the contents of the sieve tubes to be made up of dense bodies in a dense cytoplasm. At the sieve plates the protoplasm is dense even to the point of gelation. How the water could move through such a system of high resistance without destroying the collodial structure as happens in the differentiating xylem requires an explanation beyond the assumption that this protoplasm is very permeable to a mass flow of water.

Further, it has never been demonstrated that sugars and amino acids are dumped into the storage organs with a volume of water. In view of all these criticisms it would seem to me that the solution in the sieve tubes does not move as a river, but rather it seems more probable that the translocatory substances are moving in water but independently of it. For if it does not why should there be such well established gradients along which movement takes place as Mason and Maskell have so definitely shown? These could not exist if there were a mass flow, for they would be washed away more rapidly than they could be formed and one would expect a rather uniform distribution of these solutes. That the gradient pattern is important cannot be denied. Mason and Maskell have shown this to be true of carbohydrates, nitrogen compounds, and inorganic salts once they get into the phloem. The high point of the gradient is near the source, the low part near the sink. These can be reversed at the will of the investigator. It surely is probable that this gradient is significant, although we must admit that we are not aware of its meaning. Since diffusion seems to be out of the question, what other process could act on this pattern? So far at least a likely suggestion has not been made. It seems that sugars move down a very steep gradient in the phloem. It seems that each substance moves independently of other substances. It seems these substances move as though they were gases moving in air. This movement is many thousand times faster than one might expect in a system of physical diffusion. It seems that there is some impelling force operative in the phloem. It seems that the highly collodial condition of the sieve tube protoplasm is a necessary part of this mechanism. Could it be that surface forces kept active by the respiration of living substance are at play here moving these foods on their way?

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PROGRAM

of the

Eleventh Annual Meeting

of the

NORTHWEST SCIENTIFIC ASSOCIATION

December 28-29, 1934

Davenport Hotel Spokane, Washington

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Mezzanine Floor, Davenport Hotel

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MEMBERSHIP

Membership in the Association is open to anyone paying the annual dues of one dollar. Members receive, without additional cost, Northwest Science, issued quarterly, the official publication of the Association.

HEADQUARTERS

The Davenport Hotel will be the official headquarters of the Association during the meeting and all general and section meetings will be held in the hotel, except for the meeting of the Association with the Spokane County Medical Association held the evening of December 28th in the Auditorium of the Paulsen Building.

REGISTRATION

The registration desk will be found on the mezzanine floor of the Davenport Hotel. All old members should register and receive their official badge for the meeting. At the same time they should see that their dues are paid. New members should fill out a membership card and pay the annual dues.

ANNUAL DINNER
Luncheon-Breakfast

The annual dinner will be held at 6:15 P. M. on Friday, December 28, in the Elizabethan Rooms. Reservation should be made at the time of registration. Price, $1.25. Members and guests are invited to attend. Howard C. Flint, retiring President of the Association, will give the address of the evening.

There will be a Sigma Xi breakfast for members and friends on Saturday morning, December 29, at 7:45 o'clock in the East Banquet Hall. Reservations should be made at the time of registration. Price seventy-five cents.

A luncheon for members of the Northwest Scientific Association and the Asso-

ciated Engineers of Spokane will be held Friday noon in the Isabella Dining Room. W. A. Rockie of the Washington State College Soil Experiment Station will speak. Price, fifty cents.

Schedule of Meetings

Friday, December 28

9:00 A.M.—Registration, Mezzanine Floor.

9:30 A.M.—General Session, Elizabethan Rooms A, B, C.

12:00 Noon—Luncheon with Associated Engineers of Spokane.

2:00 P.M.—Sectional Meetings

Botany - Zoology. Elizabethan Rooms, B, C.

Chemistry-Physics - Mathematics. Elizabethan Rooms D. E.

Education. Room 200.

Engineers. Elizabethan Room A.

Forestry. Mandarin Room.

Geology-Geography. East Banquet Hall.

Social Science. Green Room.

3:00 P.M.—Continuation of Migratory Fish Symposium. Hall of the Doges.

6:15 P.M.—Annual Dinner. Elizabethan Rooms.

8:15 P.M.—Open Meeting. Auditorium Paulsen Medical & Dental Building.

Saturday, December 29

9:00 A.M.—Annual Business Meeting of Association. Elizabethan Rooms A, B, C.

10:00 A.M.—Sectional Meetings.

Chemistry-Physics - Mathematics. Elizabethan Rooms D, E.

Education. Room 200.

Engineers. East Banquet Hall.

Geology-Geography. East Banquet Hall.

Social Science. Green Room.

Continuation of Migratory Fish Symposium. Elizabethan Rooms A, B, C.

2:00 P.M.—Sectional Meetings

Botany-Zoology. Elizabethan Rooms B, C.

Chemistry-Physics. Elizabethan Rooms D, E.

Forestry. Mandarin Room.

Geology-Geography. East Banquet Hall.

Social Science. Green Room.

GENERAL SESSIONS

Friday, December 28

9:30-11:30 A.M.—Elizabethan Rooms A, B, C.

President Thomas Large, Chairman.

Symposium on Columbia River Migratory Fish and their Conservation.

1. "Biology of Columbia River Salmon," Willis R. Rich, Stanford University, Palo Alto, California.
2. "Research Projects of the U. S. Bureau of Fisheries in the Pacific Northwest," F. A. Davidson, Director Fisheries Biological Laboratory, Seattle, Washington.
3. "Influence of Dams and Irrigation Canals on Migratory Species of Fish in the Columbia River System," J. A. Craig, Bureau of Fisheries.
4. "Proposed Methods for Protection of Migratory Fish at the Bonneville Dam," H. B. Holmes, Bureau of Fisheries.

Announcements.

Appointment of Committees.

12:00-1:15 P. M.—NOON LUNCHEON. Elizabethan Rooms.

Joint meeting with the Associated Engineers of Spokane. Secretary, L. K. Armstrong. Speaker, W. A. Rockie, "Erosion, Run-off, Floods, and Water Supply—A Single Problem."

3:00-5:00 P. M.—Continuation of Symposium on Migratory Fish. Hall of the Doges.

5. "Value of Lampreys," W. B. Weaver
6. "Notes on Sturgeon of Snake River," T. B. Murray.
7. "Certainties and Risks of Damming Columbia River," Dr. Lawrence Griffin, Reed College, Portland, Oregon.
8. Title to be Selected. Henry D. O'Malley, Former U. S. Commissioner of Fisheries.
9. Spawning Habits of Land Locked Sockeye Salmon." Leonard P. Schultz, University of Washington, Seattle.

6:15 P. M.—ANNUAL DINNER. Elizabethan Rooms.

Address of Retiring President, Howard R. Flint, United States Forest Service, Missoula, Montana, "Scientific Relationships in the Life of a Forest."

8:15 P. M.—Auditorium Paulsen Medical and Dental Building.

Joint meeting of the Northwest Scientific Association and the Spokane County Medical Society. Dr. R. F. E. Stier, Chairman of the Medical-Surgery Section. Open to the public.

1. "The Results of Ten Years' Use of the United States Public Health Service Vaccine for the Prevention of Rocky Mountain Spotted Fever," Dr. D. Davis, Hamilton, Montana.
2. "Activities of Living Cells." Motion pictures taken through microscopes showing cell activities, cancer cells, work of phagocytes, etc. Dr. Ronald MacLennan, Washington State College, Pullman, Washington.

Saturday, December 29

9:00-10:00 A. M.—Elizabethan Rooms A, B, C.

President Thomas Large, Chairman.
Annual Business Meeting.
Reports of Officers and Committees.
Election of Officers.

SECTIONAL PROGRAMS

BOTANY-ZOOLOGY

H. F. Clements, Washington State College, Chairman.
Roy S. Rodock, Normal School, Lewiston, Idaho, Secretary.

Friday, December 28

2:00 P. M.—Elizabethan Rooms, B. C.

1. "Hepatics of the Portland Region," L. E. Griffin and E. Thurston, Reed College. 10 minutes.
2. "Nature of Fatuoids," LeRoy V. Johnson, Washington State College. 15 minutes.
3. "Life Cycle of Ichthyophthirius—a ciliate parasite on Fish," Ronald MacLennan, Washington State College. 15 minutes.
4. "Quantitative Experiments on Digestion of Wood by Zootermopsis," R. E. Hungate, Stanford University. 15 minutes.
5. "Auditory Apparatus of Chimaera," L. E. Griffin and F. Bagley, Reed College. 10 minutes.
6. "A New Leaf Spot of Grey Winter Oats," Roderick Sprague, Oregon State College. 10 minutes.
7. "Wilhelm N. Suksdorf—A Biographical Sketch," Fermen L. Pickett, Washington State College. 10 minutes.

Saturday, December 29

2:00 P. M.—Elizabethan Rooms B, C.
Election of Officers.

8. "Flora of a Scabland Lake," Fermen L. Pickett, Washington State College. 10 minutes.
9. "Can Different Degrees of Bunt Resistence be Recognized in F_2 Plants?" A. M. Schlehuber, Washington State College. 12 minutes.
10. "Ecology of Kamiak Butte," Lowell A. Mullen, University of Idaho. 15 minutes.
11. "A History of Botanical Exploration in the Pacific Northwest," Fermen L. Pickett, Washington State College.
12. "Morphology of the Pome Lenticels of the Apple," Harry F. Clements, Washington State College. 15 minutes.
13. "Observation upon Laravel Trematodes found in an Operculate Snail from the Little Spokane River," Leslie R. Hedrick, Whitworth College. 15 minutes.
14. "The First Record of the Stomach Nematode Spiroxys Contortus (Rudolphi) in Washington Turtles." Leslie R. Hedrick, Whitworth College. 5 minutes.

CHEMISTRY-PHYSICS-MATHEMATICS

G. W. Hammar, University of Idaho, Moscow, Idaho, Chairman.
L. J. Gilbertson, Washington State College, Pullman, Washington, Secretary.

Friday, December 28

2:00 P. M.—Elizabethan Rooms, D, E.

1. "The Effect of Electric Current on Nitration and Oxidation of Toluene," R. C. Kirk and W. E. Bradt, Chemistry Department, Washington State College, Pullman, Washington. 10 minutes.
2. "Straight Line Construction of Unicursal Cubic and Quartic Curves," W. H. Bunch, Mathematics Department, University of Idaho, Moscow, Idaho. 15 minutes.
3. "Some Investigations on Cosmic Rays," Dwight A. Goodwin, Department of Physics and Mathematics, Whitworth College, Spokane, Washington. 30 minutes.
4. "Some Experiences with Proton Generators," Robert L. Craig, Physics Department, University of Idaho, Moscow, Idaho. 20 minutes.
5. "Molecular Diffusion into Wood," L. C. Cady, University of Idaho, Chemistry Department, Moscow, Idaho. 15 minutes.
6. "An Oxidation Method for the Determination of Mucic Acid in the Presence of Oxalic Acid," Charles E. Moser, Chemistry Department, University of Idaho, Moscow, Idaho. 15 minutes.

Saturday, December 29

10:00 A. M.—Elizabethan Rooms D, E.

7. "An X-Ray Tube and Spectrometer," S. Town Stephenson, Physics Department, Washington State College, Pullman, Washington. 20 minutes.

8. "An Aether Drift Experiment," G. W. Hammar, Physics Department, University of Idaho, Moscow, Idaho. 15 minutes.
9. "Vapor Pressure and Dehydration of Unstable Salt Hydrates," T. Ivan Taylor, Chemistry Department, University of Idaho, Moscow, Idaho. 15 minutes.
10. "Equilibrium Moisture Content in Samples of Air Dried Cotton," Alonzo W. Martin, Chemistry Department, University of Idaho, Moscow, Idaho. 15 minutes.

2:00 P. M.—Elizabethan Rooms D, E.
Election of Officers.

11. "Methylene Blue in the Treatment of Carbon Monoxide Poisoning," H. L. Cole, Washington State College, Pullman, Washington.
12. "The Preparation of Phosphoric Acids," G. B. King, Washington State College, Pullman, Washington.
13. "The Compression of Liquids at Solid-Liquid Interfaces," J. L. Culbertson, Washington State College, Pullman, Washington.
14. "Some Condensation Products of Aromatic Aldehydes and Acyl Naphtols," Leonard Pontesso, Washington State College, Pullman, Washington.
15. "Oxidation of Lactic Acid," H. Fallscheer, Washington State College, Pullman, Washington.
16. "A Study of Student Accuracy in Qualitative Analysis," L. I. Gilbertson, Washington State College, Pullman, Washington.
17. "The Absorption of Oxygen by Iron," Louis S. Keyser, University of Idaho, Moscow, Idaho. 10 minutes.

EDUCATION

A. C. Lemon, University of Idaho, Moscow, Idaho, Chairman.
I. N. Madsen, State Normal School, Lewiston, Idaho, Secretary.

Friday, December 28

2:00 P. M.—Room 200.

1. "Personality Accounting," Dr. F. T. Hardwick, Dean, Whitworth College, Spokane, Washington.
2. "A Study of Teachers Salaries in Idaho During the Past Seven Years," Dr. I. N. Madsen, Lewiston State Normal School, Lewiston, Idaho.
3. Brief Statements of Current Research Studies at Various Institutions of the Northwest.
4. "Are Students Well Informed?" R. F. Hawk, State Normal School, Cheney, Washington.

Saturday, December 29

10:00 P. M.—Room 200.
Election of Officers.

5. "The Relation Between Student Personality and Grades Earned," Dr. C. L. Harlan, Lewiston State Normal School, Lewiston, Idaho.
6. "Increasing Intelligence," Dr. J. W. Barton, Head of the Department of Psychology, University of Idaho, Moscow, Idaho.
7. "Man a Microcosm," Walter E. Flowers, Spokane, Washington.

ENGINEERING

J. E. Buchanan, University of Idaho, Chairman.
H. C. Bender, Washington Water Power Co., Spokane, Washington, Secretary.

Friday, December 28

2:00 P. M.—Elizabethan Room A.
Election of Officers.
Program to be arranged.

Saturday, December 29

10:00 A. M.—Joint session with Geology Section in East Banquet Hall.

FORESTRY

Lyle F. Watts, U. S. Forest Service, Missoula, Montana, Chairman.
George M. Jemison, U. S. Forest Service, Missoula, Montana, Secretary.

Friday, December 28

2:00 P. M.—Mandarin Room.

1. "The New Deal and the Forest Industries in the United States." Dean T. C. Spaulding, School of Forestry, University of Montana, Missoula, Montana. 30 minutes.
2. "Recent Advances in the Solution of Economic Forest Insect Problems," W. D. Bedard, Assistant Entomologist, Coeur d'Alene, Idaho. 30 minutes.
3. "Some Phases of the Ribes Ecology Investigation in the Inland Empire." Dr. C. W. Waters, Division of the Blister Rust Control, Spokane, Washington. 30 minutes.
4. "The Spread of White Pine Blister Rust by *Ribes inerme* and *Ribes lacustre* on the Newman Lake Plot," E. L. Joy, Division of Blister Rust Control, Spokane, Washington. 30 minutes.

Saturday, December 29

2:00 P. M.—Mandarin Room.
Election of Officers.

5. "Fuel Type Mapping—Its Relation to Fire Control Planning," L. G. Hornby, Northern Rocky Mountain Forest

and Range Experiment Station, Missoula, Montana. 30 minutes.

6. "Recent Developments in the Measurement of Forest Fire Danger."
"New Devices for the Forest Fire Protectionist," Donald N. Mathews, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon. 15 minutes.
7. "The Automatic Recording of Fuel Moisture and Winds," H. T. Gisborne, Northern Rocky Mountain Forest and Range Experiment Station, Missoula, Montana. 15 minutes.
8. "The Measurement of Visibility," Dean R. E. McArdle, University of Idaho, Moscow, Idaho. 30 minutes.
9. "Lightning Storms and Fires," William G. Morris, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

GEOLOGY-GEOGRAPHY

D. C. Livingston, University of Idaho, Moscow, Idaho, Chairman.
R. L. Lupher, Washington State College, Pullman, Washington, Secretary.

Friday, December 28

2:00 P. M.—East Banquet Hall.
Symposium on Physiographic History of Northwest Streams.

1. "A 'Suspended' Valley in Grimes Creek in the Payette Canyon, Idaho."
"Drainage Patterns and Their Interpretations in the Mountains Near Boise, Idaho," Alfred L. Anderson, School of Mines, University of Idaho, Moscow, Idaho. 15 minutes each.
2. "Physiographic History of Streams of Northwestern Montana," C. H. Clapp, State University of Montana, Missoula, Montana. 15 minutes.
3. "Palouse Topography and Its Relation to Stream History," John P. Thomson, U. S. Soil Erosion Service, Pullman, Washington. 15 minutes.
4. "Some Effects of Cultivation on Stream History and Topography of the Palouse Region," A. E. Victor, U. S. Soil Erosion Service, Moscow, Idaho. 10 minutes.
5. "Physiographic History of the Northwest Quarter of Oregon," E. T. Hodge, Department of Geology, Oregon State College, Corvallis, Oregon. 15 minutes.
6. "Deformation and Stream History of the Silvies Plateau, Central Oregon," R. L. Lupher, Department of Geology, Washington State College, Pullman, Washington. 15 minutes.
7. "An Electrical Method of Soil Prospecting," R. L. Craig, Department of Physics, University of Idaho, Moscow, Idaho. 20 minutes.

Saturday, December 29

10:00 A. M.—East Banquet Hall.
Joint Session of Engineering Section with the Geology Section.
J. E. Buchanan, University of Idaho, Moscow, Idaho, Chairman.

8. "Geology of the Bonneville Dam," E. T. Hodge, Department of Geology, Oregon State College, Corvallis, Oregon 30 minutes.
9. "Some Geologic Aspects of the Damsite of Grand Coulee," H. E. Culver, Department of Geology, Washington State College, Pullman, Washington. 15 minutes.
10. "Utilization of the Power from Grand Coulee Dam," H. V. Carpenter, Washington State College, Pullman, Washington. 20 minutes.

2:00 P. M.—East Banquet Hall.
Election of Officers.

11. "Explosion Versus Engulfment of Mt. Mazama," Warren D. Smith, Department of Geology, University of Oregon, Eugene, Oregon. 30 minutes.
12. "A Rutile Deposit at Magnet Cove, Arkansas," Vernon E. Scheid, School of Mines, University of Idaho, Moscow, Idaho. 20 minutes.
13. "The Kruger Alkaline Syenites of Northern Washington and Southern British Columbia," Charles D. Campbell, Department of Geology, Washington State College, Pullman, Washington. 15 minutes.
10. "The Sulphur Deposits of the Summit of Mt. Adams, Washington," Claude S. Fowler, Department of Geology, Washington State College, Pullman, Washington. 15 minutes.
15. "Geology of the Gold Deposits of Thunder Mountain and Yellowpine, Idaho," D. C. Livingston, Harvard, Idaho. 15 minutes.
16. "A Summary of the Known Occurences of Gold in Washington," Everett Hougland, State of Washington, Division of Geology, Pullman, Washington. 15 minutes.

SOCIAL SCIENCE

Claudius O. Johnson, Washington State College, Pullman, Washington, Chairman.
P. C. Phillips, University of Montana, Missoula, Montana, Vice-Chairman.
C. R. Randall, North Central High School, Spokane, Washington, Secretary.

Friday, December 28

2:00 P. M.—Green Room.

1. "Soil Surveys, Land Classification, and Land Uses," Professor W. L. Powers, Soil Scientist, Oregon State College, Corvallis, Oregon.
2. "Some Notes on Ancient Culture of the Provo Salt Lake Region," Professor Albert B. Regan, Department of Anthropology, Brigham Young University, Provo, Utah.
3. "Population Trends in Washington: A Specific Example of a Method of Instituting Class Research by Isopleth Maps," Victor Roterus, Instructor in Economic Geography, Washington State College, Pullman, Washington.

Saturday, December 29

10:00 A. M.—Green Room.

4. "Early Missionaries in the Northwest," Reverend Thomas Maher, S. J., Professor of History, Gonzaga University, Spokane, Washington.
5. "A Study of Colonial Indian Trade," Curtis Zimmerman, Newport High School, Newport, Washington.
6. "A High School Teacher's View of Our Social Science Program," Charles R. Randall, North Central High School, Spokane, Washington.

2:00 P. M.—Green Room.

Election of Officers.

7. "The Sociology of a Prison Community," Professor Edward W. Voelker, Department of Sociology, University of Idaho, Moscow, Idaho.
8. "Backgrounds of Juvenile Transiency," Dr. James G. Patrick, Federal Transient Service, Spokane, Washington.

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1000 Washington Ave. Brooklyn, N. Y., U. S. A.

NORTHWEST SCIENCE

FEBRUARY, 1935

Vol. IX No. 1

SMITHSONIAN INSTITUTION
MAR 5 1935
NATIONAL MUSEUM

Published by

The Northwest Scientific Association

Single Copies Thirty-five Cents

THE
C. M. FASSETT
CO., Inc.
N. 207-11 Wall St., Spokane, Wn.

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ARTHUR E. PETERSON, Pres.

-:- NORTHWEST SCIENCE -:-

A scientific journal devoted to the dissemination of scientific knowledge and encouragement of research in the Pacific Northwest

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Is Entered as Second Class Matter, April 5, 1927, at the Postoffice at Cheney, Washington. Office of Publication, Cheney, Washington. Subscription Price to Members, Including Dues, One Dollar per Year; to Non-Members, One Dollar.
Volumes I. to VIII., 1927 to 1933, Each $1.25.

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MAR

-:- EDITORIAL COMMENT -:-

ELEVENTH ANNUAL MEETING

The 1934 meeting had more members registering their attendance than any previous meeting. This, in the face of a number of hindering circumstances, must be interpreted as showing definite access of strength in our organization.

We are indebted to Stanford University for making it possible for Dr. Willis H. Rich and Mrs. Rich to attend this meeting. Their contribution to the success of this gathering was notable.

The recommendation of Retiring President Flint that a change be made from the older method of alternating the presidency of N. W. S. A. among the northwest states to alternating it among representatives of the various disciplines of science was adopted.

Illness and other duties prevented attendance of a number of our very faithful members. President Clapp of Montana University and Dr. Elrod of that institution could not attend because of continued illness. Dr. Hubert and Professor Hungate of the Council were absent because of illness in their families. A session of the Montana Legislature made it advisable for Presidents Thomson and Atkison of the School of Mines and the State College of that state to remain at home. President Holland of Washington State College was not at any time far away from the sessions but matters relating to their building program seemed to prevent attendance.

Dean Crawford, Past President and Councilor, represented N. W. S. A. on the Council of A. A. A. S. at Pittsbugh.

THE SYMPOSIUM

This issue of Northwest Science is devoted to the papers presented in this Symposium. It seems that interest in these papers has been far greater outside our territory than within it. This can only be interpreted as proof of the great need of our people and scientific workers for information on a very vital topic. This state of affairs became evident early in the attempt to have this subject presented at this meeting. No responses came from the colleges of the Inland Empire. A similar situation prevailed at the meeting of the Committee on Fisheries of the Regional Planning Board in Seattle, December 12-14, a meeting of fisheries people of approximately 100, chiefly technicians and scientists, was practically without representation from the interior. ''Aquiculture'' has not yet ''arrived'' in the Inland Empire. When it does we hope it will not be too late. The papers here presented furnish the strongest possible support to those working for adequate appropriations for fishways over the Bonneville dam. Perhaps the most difficult idea to ''get over'' with the general public (and scientists?) is that when a run of Pacific salmon is stopped before it reaches its spawning grounds its progeny is destroyed absolutely. They die and do not return to spawn another year as a ''steelhead'' or an Atlantic salmon might.

NEW PRESIDENT

Mr. William A. Rockie, the new President of N. W. S. A., is a native of Nebraska and a graduate of Nebraska University. He has seen long service in scientific investigation for the United States Government, having served in the Bureau of Soils and the Office of Blister Rust Control for approximately twenty years. At present he is Superintendent of Soil Erosion Investigations of the Bureau of Chemistry and Soils in the Pacific Northwest.

DR HUBERT'S RESIGNATION

All members of Northwest Scientific Association will regret Dr. Hubert's decision to withdraw from the editorship of Northwest Science. Since the issue of March, 1930, he has faithfully served the Association in this rather thankless position. That Northwest Science is a presentable magazine of science is due chiefly to his devotion to our interests. Only three volumes of its eight volumes had appeared when he took charge. The present arrangement for his successor is only temporary and when the proper person appears to undertake this important work he will be selected. That a hasty appointment was made in this case is entirely due to the desirability of quickly getting the papers of the Fish Symposium into print so they may be available for a wider audience. Changes which may appear in this issue are due to the necessity of getting a considerable amount of material into type with a limited sum of money.

NORTHWEST SCIENCE

VOL. IX. FEBRUARY, 1935 NO. 1

The Association is not responsible, as a body, for the facts and opinions advanced in the papers published by it.

The Biology of the Columbia River Salmon

DR. WILLIS H. RICH
Professor of Biology, Stanford University

When I was first asked to take a part in this symposium on the probable effect of dams on the fish life of the Columbia River it seemed to me that I could not do better than to present, as a sort of introduction to the more particular and important discussions, a general account of the biology of the Columbia River salmon—and it is this that I purpose now to do. I shall confine myself to a brief treatment of those particular phases of the biology of the salmon that will, in my opinion, be of importance as a basis for the subsequent discussions and that will have to be taken into consideration in formulating any well ordered plan for the conservation of the valuable natural resource that these fish constitute. None of the facts that I shall present are new and to some of you they may appear to be merely a repetition of very ancient history; but I still think that I cannot contribute more toward the discussion and toward a clarification of the problems before us than to review these pertinent and fundamental points in the life history of the salmon.

The salmon runs of the Pacific streams were among the wonders that astounded the early explorers and most of them had more or less to say about them. The tremendous shoals of large and delicious fish, rich in food value, that entered the streams from the sea and often made remarkable journeys of hundreds or thousands of miles to the upper reaches of the largest rivers of the northwest must have been impressive. And, for the earliest settlers, as for the aborigines who preceded them, the presence of these fish must have meant much in the way of such economic security as they enjoyed. Later, in the period of expansion and development of the west that followed the Civil War, the salmon canning industry on the Columbia River was started, proved successful and grew rapidly until it was, as it still is, albeit rather precariously, one of the major industries of the region.

As the industry grew and took, gradually, year after year, more and more salmon from the Columbia River runs some question arose in the minds of some of the more thoughtful fishermen and canners as to just how far they could go, as to just how many fish they could take without cutting off the supply at its source. To some this seemed a remote possibility—did not the fish come in from the sea year after year and could not the sea supply indefinitely? But others, less trustful of the sea, or, perhaps, just more observing, suspected that it was not all quite as simple as that and that the taking of too many fish at one time might reduce the supply in future years. Probably most of the men engaged in the salmon industry were little inclined to let this possibility worry them even if they admitted it—they were naturally concerned chiefly in "getting their share" of the fish while there were fish to get. But some few were inclined to look farther into the future and to recognize the fact that here was a natural resource of great value which could be made perpetual by proper handling or could be wiped out completely

in a comparatively few years by unwise and injudicious use. In this these few practical business men were joined by a number of men of scientific training who were interested especially in the conservation of our natural resources and, some of them, particularly in the conservation of the salmon. And out of this interest was born the biological study of the salmon of the Pacific Coast because it was early recognized that the conservation—the wise use—of such a biological resource involves an understanding of the biology and particularly of the ecology of the species involved. And, to such an assembly as this, it may appropriately be pointed out that, in due time, came from these investigations, quite directly, the entire development of what we now know in America as Fishery Science and which is being applied to the cod and mackerel fisheries of New England, to the shrimp fisheries of the Gulf and South Atlantic, to the sardine and tuna fisheries of southern California and to the halibut and salmon fisheries of the North Pacific.

The first biological studies out of which came all this development were done right here in the northwest when David Starr Jordan, Barton Warren Evermann and Charles Henry Gilbert undertook to study the salmon of the Columbia River and, among other things, worked on the salmon of the Redfish Lakes of Idaho. From the point of view of our present knowledge of salmon not so much was accomplished by these earliest investigations other than to determine some of the more general features of the biology of the salmon. The study of the salmon was, however, given a remarkable impetus in 1909 when Doctor Gilbert took up the detailed study of the Pacific salmon based on the microscopic examination of the scales after the method used by Dahl in Norway and by Johnston in England. Gilbert made use of this method with conspicuous success in his extensive studies of the salmon including those of the Columbia River. I had the good fortune to be one of his graduate students just at the time he was beginning this study and it was not long before I was working in the same field. It has now been just a little over twenty years since I first came onto the Columbia to study its salmon. When my own participation was interrupted by other duties, Mr. Harlan B. Holmes took up the investigation and after various interruptions is still at it.

In speaking of the biological studies of the salmon of the Pacific Coast I cannot let pass the opportunity to point out that the conducting of such studies requires the whole-hearted interest and support of administrators and to say that, on this account, for our present considerable knowledge of the biology of the salmon of the Columbia River and of the entire Northwest and Alaska, we owe more to the former Commissioner of Fisheries, Mr. Henry O'Malley, than to any other man.

When any biologist tackles a problem the first thing that he must know is the kind of organisms with which he is dealing—their names and relationships. This is necessary, if for no other reason, in order that he may speak definitely about them and in such a way that there can be no doubt as to what forms are being considered. With this necessity in mind it will be well to discuss very briefly the species of Pacific salmon, especially those that are to be found in the Columbia River.

The word "salmon" was, of course, first applied to the European, Atlantic salmon—the fish that was so highly esteemed that to poach salmon was at one time a capital offense. The same fish, or possibly a sub-species, was found in many of the streams of our east coast when the country was first colonized—and a few still survive in the streams of Maine, Canada and Newfoundland. And when the fishes of the west were first seen it was natural to apply the same common name to all of the large salmonoid fishes that were to be found here. Ichthyologists, however, ultimately sorted these western salmon out into two distinct groups, one

including a fish almost the same as the Atlantic Salmon and placed in the same genus, *Salmo* and another group differing considerably from *Salmo* in habits and in certain morphological details although not so much in superficial appearance, the genus *Oncorhynchus* (Hooknose). Now, by a curious inversion, the fishes of the genus *Oncorhynchus* have come to be known commonly as salmon while our western *Salmo* has come to be known as the Steelhead Trout although it is actually much more like the original salmon of the Atlantic than is our *Oncorhynchus*

The steelhead, *Salmo gairdneri or S. irideus* is widely distributed along the coast from well below Monterey to the arctic waters of Bering Sea. The species is found in fairly large numbers in the Columbia River but no detailed study has been made of its habits. It is closely related to the rainbow trout—so closely related that ichthyologists are not yet agreed as to the exact relationship. One fairly acceptable theory, in my opinion, is that the rainbow is a form of the steelhead that has given up the habit of going to sea, in other words has become "landlocked," and that, in some cases at least, these landlocked forms have remained either physically or physiologically isolated long enough to have developed morphological differences that may be considered at least as sub-specific.

In the genus *Oncorhynchus* there are, in North America, five distinct species: *O. tschawytscha*, the Chinook or King salmon; *O. nerka* the sockeye, blueback or red salmon; *O. kisutch* , the silver or coho salmon; *O. gorbuscha*, the pink or humpback salmon, and *O. keta*, the chum or dog salmon. The pink salmon is not found in the Columbia River in commercial quantities—in some eight summers spent on the river I think that I saw not more than a couple of dozen individuals of this species. Its range is chiefly from Puget Sound northward practically to the Arctic coast and well down on the Asiatic coast as well. The other four species all enter the commercial catch of the Columbia River but the catch of Chinooks far overshadows in importance that of all other species combined. The chum salmon, also is of relatively slight importance on account of the relatively poor quality of the canned product—and it is of still less importance to the present discussion on account of the fact that it tends to breed only in the lower tributaries of the river and seldom, if ever, ascends the Columbia above the mouth of the Willamette. We may consider, then, that for our present purposes, three species of salmon only are of importance—the silver, blueback and Chinook.

Before discussing some of the details in the life histories of these important species it will be well to present some of the more general features of life history that are common to all of the species and to describe some of the methods of study that have been used.

All of the species of Pacific salmon and also the steelhead are anadromous, that is to say, they are fishes that spend a large part of their lives in the sea but enter fresh water for reproduction. The eggs are laid in the gravel of streams, or occasionally along the shores of lakes, are covered with gravel by the parent fish and remain here until hatching. The length of time required for incubation varies with the species and also with the temperature of the water. In the case of Chinook salmon the eggs will hatch in about fifty days at a temperature of 50 degrees Fahrenheit. Within a short range about this temperature each degree higher shortens the incubation about two and a half days and each degree lower lengthens the incubation period by an equal amount. Upon hatching the young fish are encumbered by a relatively enormous yolk sac and are practically helpless. They remain, therefore, in the gravel until this yolk sac has become almost completely absorbed. After the absorption of the yolk sac the young emerge from the gravel and begin to feed. They remain in fresh water for varying

lengths of time but ultimately migrate down stream to the sea. The growth in fresh water is relatively slow so that the young, on their seaward migration, are small fish, ranging from only about an inch to some six or eight inches in length depending in part on the length of time spent in fresh water, and, in part, on the favorableness of the environmental conditions, abundance of food, etc.

Of the life in the sea not much is known; the fish are seldom seen in the sea except in the vicinity of the coasts. Only the chinook and silver salmon are taken in commercial quantities in the sea but these two species are taken in rather large numbers by hook and line all the way from Monterey Bay to the coast of Southeastern Alaska. These two species, and also the steelhead, apparently feed largely upon small fish, such as herring and sand launces, but the other three species, the sockeye or blueback, pink and chum feed largely upon the smaller plankton organisms that are found floating in abundance in the open ocean but particularly in the region of the continental shelf. The relatively great abundance of food in the sea, and possibly other factors, reacts promptly and vigorously upon the rate of growth and the fish increase in size with great rapidity during their life in the sea. After one or more seasons spent in this environment the fish return to fresh water for spawning. The length of time spent at sea differs considerably with the species and with the locality and, in the case of some of the species, there is a considerable difference with individuals even in the same locality. On entering the streams for the spawning migration some of the species in some localities may pass up only a few yards—sometimes not even out of the range of brackish water—while others ascend the streams for hundreds of miles to the headwaters of some of our largest rivers such as the Columbia, the Fraser and the Yukon.

Except in rare instances and under peculiar conditions the adult fish after leaving the sea do not feed but live throughout the spawning journey upon the fat that was elaborated during the period of heavy feeding in the sea and stored between the layers of muscle. This source of energy is drawn upon for the journey up stream to the spawning grounds and for materials for the development of the large masses of eggs and sperm. As a result, the fish, by the time the spawning activities are over, are greatly emaciated, weigh perhaps not more than half what they did on leaving the sea, are often infected with fungus as a result of injuries received on the journey or on the spawning grounds and are altogether in a sad state. A certain percentage, probably rather small, of our steelhead survive this period of stress, successfully make the return journey to the sea where they may recover and live to spawn again; but nature has evidently failed to provide for such survival in the case of all the species of the genus *Oncorhynchus*. No one of these ever returns to the sea there to recover, produce another lot of eggs or sperm and return to fresh water to spawn a second time. Without exception these fish die after spawning.

Most of these general features of the life history of the salmon were discovered by the earlier investigators—or at least were first reported by them. I presume that many of these facts were known to the earlier settlers and fishermen and by the Indians who preceded them and were fairly good ecologists themselves. However, many of the facts were corroborated and important details added by the application of the scale method of study which, as I have mentioned, was begun in this country by Dr. Gilbert. This method is based upon the fact that, on the outside of each scale there are a series of concentric rings, or partial rings, the circuli, and that the width of the rings is dependent quite largely upon the rate of growth at the time the scale was laid down. The scales grow by accretions at the margins and, approximately, at the same relative rate as the fish as a whole,

while there is a tendency for the rings to be laid down at equal intervals of time. Now during a part of the year, spring and summer usually, the fish are growing much more rapidly than they are growing during the fall and winter so that the result is that, for each year's growth there is laid down on the scale a band of wide rings and a band of narrow rings—the whole of this double band being termed an annulus or annular ring. The interpretation of the scales is not often quite as simple as this because there are various other causes of variation in the growth rate other than those that are associated with the seasonal changes; but this is the principle upon which the determination of age by means of scales is based.

Another very interesting feature of scale growth is the formation of what are known as "spawning marks" on the scales of the Atlantic salmon and of the steelhead—fishes which, as I have just said, may recover from the strain of the spawning period, return to the sea and live to spawn another day. In all of these anadromous salmonoids the scales are apparently broken down at their margins and partially resorbed during the long fast of the spawning journey so that the edges of the scales present a torn and ragged appearance. Often the scales are so reduced in size that it is difficult to find them in the thickened skin of the spawning fish and the diameter may be less than a half that of the scales at the time the fish left the sea. In the case of the Atlantic salmon and the steelhead this absorbed portion of the scale is repaired when the fish returns to the sea and new circuli are added at the new margin outside of the repaired area. In the repaired portion, however, the circuli are not repaired as originally laid down but the new circuli follow more or less the line of the new margin so that there is usually a definite unconformity between the original circuli of the old part of the scale and the new circuli. Usually, too, there is a narrow space on which no circuli are to be found between the old and the new circuli. The entire scale scar is a very definite thing, quite easily recognized and almost impossible to confuse with anything else in the way of a scale abnormality. As a result of this it is possible to determine with considerable accuracy the number of times that steelhead may spawn and, while no detailed studies have been made, it is known that some of them have spawned three times and a few have been taken in their fourth spawning migration. It is a very interesting and significant thing, however, that in tens of thousands of Pacific salmon scales that have been examined no one has ever been found with an undoubted spawning mark. This constitutes the most definite and conclusive evidence we have that the salmon of the genus *Oncorhynchus* all die after spawning.

In addition to the microscopic examination of scales two other methods of study, experimental in nature, have been applied to the investigation of the salmon—the method of marking young fish so that they can be identified on their return as adults and the method of tagging adult fish so that, when recaptured, they can be identified.

The most successful method of marking has been by the removal of certain of the fins, such as the adipose and one or the other of the ventrals. There can obviously be several combinations of fins so that several experiments on the same species can be carried on simultaneously. After the young fish are marked they are liberated and the future runs of adult fish are watched carefully for the appearance of fish lacking the particular fins that had been removed. Usually a reward is offered to the fishermen and cannery workers for the discovery and return of the data respecting the marked fish. It may seem that it would be like hunting for a needle in a hay stack to go forth looking for marked fish among the great numbers that constitute the commercial catch—but I have had the interesting experience of

recovering approximately fifty marked salmon in one day by simply watching at the chute down which the fish were passing on the way from a bin to the cleaning machine. Such marking experiments as these have been carried on on a very extensive scale here in the northwest and in Alaska. Several years ago the total number of fish that had been marked exceeded two millions and I presume that it is now well toward the three million mark although this method of study has not been in quite as extensive use for the past few years as it was for a time. The results secured by this method have been of the greatest importance. Marking experiments have checked the results of scale studies so that we have confidence in our interpretation of age; they have given us clues to the proper interpretation of difficult types of scale growth, and have given data as to the relative success of different methods and practices in artificial propagation and of the survival in the sea of seaward migrants of different ages and races in a state of nature and have proved beyond question the essential truth of the so-called Parent Stream Theory, of which I shall speak more later.

In the tagging experiments adult salmon have been taken by gear used in the commercial fishery—traps, purse seines and hook and line—and to each fish has been attached a numbered aluminum tag similar to those used in tagging cattle and sheep. After the tags are attached the fish are liberated and a reward is offered for the return of the tag with the date and locality of recovery. The results of such experiments have given information of the greatest value relative to the oceanic migrations of the salmon and, through this, of the extent to which various runs are being exploited. Of this also I shall have more to say later.

I wish now to give in very brief outline the features of the life histories of the Pacific salmon that are peculiar to the different species. The simplest life history of all is that of the pink salmon. The young of this species leave the fresh water for the sea almost immediately after the yolk sac is absorbed—usually in the early spring—and the fish remain in the sea about a year and a half until their total age is approximately two years, when they become mature and return to fresh water to spawn and die. So far as we know there is no variation from this simple life history.

The chum salmon introduces one kind of variation into the life history. The young of this species also leave the fresh water as soon as they emerge from the gravel but their stay in the ocean is more variable—some may return to spawn at the age of two years, as do the pink salmon, but the majority of them do not spawn until three, four or five years old.

In the life history of the silver salmon we find another kind of variation. These fish invariably remain in fresh water for at least one year before migrating to the sea, by which time they are from three to five inches in length. They usually make the seaward migration in the second spring of their lives—approximately eighteen months from the time the eggs are laid down. In the northern part of their range, however, a certain proportion of the silver salmon remain in fresh water for two years and some, possibly, for three years. In their life in the ocean the silver salmon resemble closely the pinks in that they almost invariably remain in the sea over two seasons, returning to fresh water in the second fall following the spring in which they went to sea. Only a few of the male silvers mature in the fall immediately following the seaward migration. These precociously mature males are often referred to as "grilse," following the nomenclature applied to the Atlantic salmon in England and Scotland. In the case of the Columbia River silver salmon the life history is quite uniform. There the fish usually, if not invariably, remain in fresh water until the second spring, migrating to sea, however, in the spring of their second year, remain at sea for the remainder of

that year and until the fall of their third year, when they return to spawn and die.

The habits of the sockeye or blueback and of the Chinook are considerably more complicated since both of these species remain in fresh water for varying lengths of time and also vary greatly in the number of years spent in the ocean before maturing. The sockeye, also, differs from all of the other species of salmon in that the eggs are almost invariably laid down in streams that are tributary to lakes—or along the shores of the lakes themselves. The young, on emerging from the gravel, descend to the lake, if they are in the streams above the lake, and they live then in the lakes for at least one year, often for two or three years, and occasionally for four full years before undertaking the seaward migration. During this period of life in the lake they feed upon plankton, chiefly copepods and cladocerans, and their rate of growth and survival is apparently, as would be expected, dependent directly upon the abundance of these forms. When they finally migrate to sea in the spring or early summer, they range from two and a half or three to six or seven inches in length. In the sea this species continues to feed chiefly upon plankton but, of course, the oceanic plankton is much more abundant and the plankton forms are larger so that the food supply is adequate for the much more rapid growth that takes place in the sea. Some few of the males may mature as grilse in the fall of the same year in which the seaward migration was made but usually these fish spend from two to three years at sea and sometimes do not return until the fifth year after entering the sea. With such a range of variation in both fresh water and ocean life it is obvious that there may be a great number of age groups. Thus there may be fish that left the stream during their second year and returned in either the second, third, fourth, fifth, sixth or seventh years. Or fish that left the stream during their third year and returned either in their third, fourth, fifth, sixth or seventh years and so on. As a matter of fact, Doctor Gilbert found, in the red salmon runs of Karluk River, seventeen such categories.

The Chinook varies as widely as does the sockeye in respect of its life in the sea but there is not just the same variation in its fresh-water life. The young of this species may pass on to life in the sea soon after emerging from the gravel—just as in the case of the pink and chum—or they may remain in fresh water an entire year. In the northern part of their range, say in Alaska, some of them undoubtedly remain in the streams for at least two years. Not only are there the complications that arise from such variations but the interpretation of the scales is made especially difficult because of the fact that the Chinook, at least in the Columbia River, does not seem to have such a definite time for the seaward migration as is true of the other species and even of the Chinook in some other streams. Especially during the first year of their lives the Chinook of the Columbia River may migrate at any season of the year—young fish of the brood of the previous fall may be found, even in the estuary, during practically every month from December until the following fall. This habit made the determination of age by means of the scales particularly difficult although it is now possible to interpret the scales with reasonable accuracy.

The life history of the steelhead resembles in general that of the Chinook salmon with this difference, that, so far as known, the young never migrate to sea until at least the spring of their second year—when about a year old. The steelhead spawns usually in the winter and spring instead of in the fall as do the salmon of the genus *Oncorhynchus*. The young steelhead may remain in fresh water for from one to three years, possibly more, and the fish may remain in the sea for from one to three or four years before returning to spawn. In addition, there is, of course, the additional complication

brought about by the fact that these fish may survive the stress of spawning and may spawn a second, third or fourth time.

In discussing the general features of the biology of the salmon I reserved for later consideration certain matters that are of particular importance in any consideration of the effect of the dams on the fish life of the Columbia River.

First among these is the question of the homing instinct. Very early in the history of salmon investigations on the Pacific Coast Doctor Jordan formulated a theory that has been widely known as the "Parent Stream Theory" and which states, in effect, that the salmon, when mature, return from the sea to the streams from whence they came. The evidence on which this theory was doubtlessly originally based was the fact that the fish inhabiting different streams often differ distinctly in several ways—they may differ in size or in other morphological characteristics so that they are readily separated merely on the basis of external appearance; or they may differ in their chemical composition particularly in respect of the amount of fat contained in the muscles; or they may differ in such features of the life history as the time of entering fresh water from the sea on their spawning migration. Observation of such differences as these naturally led the earlier students of salmon to the conclusion that the fish in different streams constituted separate colonies which were self-perpetuating; and, as a corollary, it followed that, in order to maintain such independent colonies it was necessary that the adult fish should return to these same streams in which they had spent the early part of their lives. More recently scale studies and marking experiments have checked and corroborated the observational evidence of independent colonies or races in the different streams and have added materially to our knowledge of these races. The scales of fish from different streams are often so distinct that anyone well acquainted with them can readily identify a small sample as belonging to a race inhabiting a certain stream. For instance I believe that I could tell with considerable certainty whether a random sample of scales from ten red salmon came from the run to the Karluk River or not.

Still better evidence of the existence of races has come from the many marking experiments that have been carried on for the past twenty-five years. In these there have been very few instances in which a marked fish has been taken in any stream other than the one in which it was reared. Numerous such experiments have been conducted with steelhead, Chinooks, silver salmon and bluebacks or sockeye and for these species there has been, so far as I know, no single unquestionable instance in which a marked fish has been taken in any other than the parent stream. Recent experiments with pink salmon conducted by Dr. F. A. Davidson have indicated that the homing instinct may not hold quite as rigidly for this species but even with these the majority of recovered marked fish were taken from the stream in which they were reared and marked. One feature of the homing of salmon should be made clear and that is that the fish return to the stream in which they were reared and not to the stream into which their parents went to spawn. If the eggs are taken from one stream to another and are there hatched and the young liberated the adults surviving from such a brood will return to the stream in which they spent the early part of their lives and not to the stream of the parents. On this account it has been suggested that the term "Parent Stream Theory" should be modified to "Home Stream Theory."

The question may arise as to whether these observed differences may not be due to environmental conditions rather than to genetic differences. However, a series of marking experiments started on the Columbia River nearly twenty years ago proved quite conclusively that the racial differences were inherited. Sockeyes or red salmon (*O. nerka*) were

brought down from Alaska, hatched, reared and marked at the Bonneville hatchery and liberated into the creek on which the hatchery is located only a short distance above the point where the creek flows into the Columbia River. In due time the adults came back, unmistakably marked, and entered the creek at Bonneville in which they had been reared and from which they had departed some two years earlier. Eggs were then taken from these marked adults and a second generation reared, marked and liberated and these in turn, as mature fish, returned to the Columbia River and to the same little tributary that had been their home for the first year or so of their lives. This in itself was, of course, the strongest sort of proof of the validity of the Home Stream Theory but it provided also striking evidence of the hereditary nature of some at least of the characteristics that distinguish races of salmon. The Alaska reds, although of the same species, were distinctly different from the Columbia River bluebacks that were running at the same time that these introduced fish entered the river. The Alaska fish were much larger—averaging about five pounds in weight as compared with about three pounds for the Columbia River fish—were much lighter in color and the flesh had only about one half as much oil. As you know, the quality of canned salmon depends in large part upon the abundance of oil and the difference between the native Columbia River blueback and the imported Alaska reds was so great that it was necessary to can the fish separately as two distinct grades. Here was a distinct chemical difference between two races of salmon of the same species and the accompanying morphological differences were so great that the men handling the fish on the cannery floor readily sorted out the two races so that they could be packed separately. Now one important and interesting thing about this was the fact that these differences persisted through at least two generations in spite of the certain profound changes in the early environmental conditions—an Alaskan lake being replaced by a hatchery pond in Oregon—and also of the probable change in conditions during the life in the sea. It seems that we are quite justified in assuming that many of the characters that distinguish races of salmon are hereditary and arise in the same way that other hereditary differences arise and will be as permanent. I do not mean to say that all of the differences that may be observed between the races of salmon are hereditary but certainly this is true of some of the more important differences.

One other important fact of particular significance to the present discussion has come from the scale studies and marking experiments—the fact that the fish return, not only to the same main stream, but also to the same tributary of a river system in which their lives began. The scales of fish spawning in different tributaries are often very distinct—just as distinct in fact as are the scales of fish inhabiting entirely separate streams—and marking experiments have corroborated this observation and have shown that the Home Stream Theory holds to a remarkable degree for the home tributary. Fish marked at the hatcheries at Bonneville, Hermann Creek, Little White Salmon, Big White Salmon, the McKenzie and Willamette Rivers and on the Klamath River in California have returned to their home tributaries in large numbers and have only rarely been taken on the spawning grounds of any other tributary. It is probably true that the Home Stream Theory does not hold quite as rigidly in the case of tributary streams as it does for independent river or stream systems but the evidence is overwhelming that, for all practical purposes, we must consider that the fish return not only to the main stream of their nativity but also to the very tributary from whence they came.

I am quite aware that the acceptance of the Home Stream Theory involves the

assumption of a degree of intelligence on the part of the salmon that some eminent biologists are not willing to grant. It involves investing the salmon with something akin to memory and an ability to distinguish relatively small differences in environmental conditions and to select the one of these which they, somehow, recognize as favorable. In many cases it is difficult or impossible for us to conceive just what the guiding environmental factors may be—just, perhaps, as it is difficult to conceive just how even a primitive memory can be seated in such a simple brain as that of a fish. But I think that we are forced to grant that both are facts—that there are environmental conditions that are recognized by the salmon and that the memory of the conditions met with on the seaward migration is stored up somewhere in that simple central nervous system to be used ultimately in directing the return migration. As a matter of fact, it seems to me relatively unimportant, certainly from a practical standpoint, how the fish manage to find their way back to the home stream. The important thing is to know whether they do or do not and the evidence in favor of the Home Stream Theory both as applied to independent streams and to tributaries is so clear cut that it is difficult for me to understand how any one, acquainted with the evidence, can question the fact regardless of how difficult it may be to explain the processes by means of which the return is brought about.

I should like now to go back and add to the brief statement already made relative to the distinct races to be found in the different tributaries of the Columbia River. Unfortunately there is not as much known about these races as should be but certain general facts are well known that are of considerable importance in the consideration of the effect of the dams. These dams, obviously, threaten to destroy the salmon runs of the part of the river that lies above these projects. Whether the threatened destruction can be averted in one way or another is quite a different matter—the threat still exists. And this destruction, if it occurs, will result mainly from the action of the dams in either preventing the ascent of spawning fish or the descent of the young on their seaward migration—or both.

In the light of the Home Stream Theory the destruction of the salmon runs above the dams will obviously mean the loss of certain races which, once exterminated, will be lost forever. It is probably impossible with our present knowledge to say just what proportion of the Columbia River runs spawn in the main Columbia and its tributaries above each of the dams but certainly the proportion that spawns above the site of the Bonneville dam is a very large one. In the first place all of the surviving races of bluebacks spawn above this lowest dam. This species was originally of much more importance in the Columbia River pack than it is today and I recall a statement of one of the pioneer packers, Mr. Frank Seufert, to the effect that the high reputation of canned Columbia River salmon was based in large part upon the pack of bluebacks in the early years of the industry. These fish, as I have mentioned above, almost invariably spawn in lakes or in the streams tributary to lakes and they originally occupied most of the high lakes in the Columbia basin above the junction of the Columbia and Snake Rivers. They were found in Wallowa Lake, the Payette Lakes, the Redfish Lakes of Idaho, the lakes of the Yakima system and in many more of the lakes of the upper Columbia. Most of the races of blueback that inhabited these lakes are now extinct as a result of the construction of dams and irrigation canals—the dams preventing the adults from entering the lakes and the irrigation canals diverting the young fish on their seaward migration out of the rivers and onto the fields—where, no doubt, they made excellent fertilizer.

The races of Chinooks inhabiting the

Columbia River above Bonneville are not only of importance on account of the fact that they form a large part of the runs into the river but because of the fact that the so-called spring run of salmon is composed almost entirely of these races. These "spring" salmon enter the river from the sea in the spring and early summer and are of exceptionally fine quality, of good color and rich in oil. The "fall" salmon, entering the river during the latter part of the summer and the fall are of poorer quality and are packed as a cheaper grade. With the exception of those spring fish that spawn in the Willamette system I believe that all of them originate in the spawning grounds of the upper Columbia, above Bonneville. Their early entry into the river and the higher percentage of oil are definitely associated with the fact that they have a longer journey to make between the feeding grounds of the sea and the spawning grounds. The journey is not only longer but harder, requiring as it does the passage of rapids and falls, and demands a greater amount of energy which is stored in the form of oil. It is chiefly, then, these races of the finest of the Columbia River Chinooks that are threatened with extermination.

The value of these runs of Columbia River Chinooks lies not alone in their importance to the Columbia River fishery but also to the important part they play in the extensive troll fishery that is carried on off shore all the way from Monterey to Southeastern Alaska. I have mentioned the tagging experiments and the importance of the data secured by this means to our understanding of the extent to which various runs of salmon are being exploited. A series of these experiments has been conducted off the coasts of Alaska and British Columbia in which Chinooks taken by troll were tagged and released as a means of determining the streams from which they came and the routes of migration from the feeding grounds at sea to the home streams. The results have added greatly to our understanding of the importance of the salmon resources of the Columbia River since they show conclusively, I think, that, especially northward from the mouth of the Columbia as far as Sitka, Alaska, a large part of the fish taken in the troll fishery come from this river. The data are not all readily available to me but I believe that there were more of these tagged fish recovered in the Columbia River than in all other streams together. Just what percentage of these belonged to the races inhabiting the upper Columbia no one knows but it is safe to assume that it is high.

There are a number of other phases of the biology of the salmon that might be profitably discussed at length but I shall not attempt to do so here. I wish only to make one last point.

The natural resources of the world fall, in general, into three main categories, sharply delimited and widely different in respect of the possibilities for conservation. One type of natural resource is that represented by minerals, coal, oil, etc., of which there is only a limited amount and for which there is no possibility of renewal once this amount is exhausted. Conservation of such a resource can only mean the prevention of waste. The second type is represented by such resources as water power which are, within limits, inexhaustable and invariable and are entirely unaffected by either use or disuse—there will be just as much water power a hundred years from now whether it is used in the meanwhile or not. Perhaps, too, in a general way, the agricultural resources, or at least the agricultural possibilities, should be placed in this category because these possibilities are not much affected by use or disuse except as the soil may be depleted and even this will recover naturally in time if left alone. The third type of natural resource is the biological resource such as the forests, the salmon, the beaver, the buffalo and the passenger pigeon. These biological resources are peculiar in that they are

readily exhausted and completely destroyed by careless over-exploitation and yet, properly conserved, can continue indefinitely to supply materials for the comfort, pleasure and maintenance of man. It well behooves man, therefore, to take good thought of the morrow before running too great risk of the destruction of such an important natural resource as that of the salmon runs of the Columbia River.

AN EDITOR VISITED OUR DECEMBER MEETING

To be able to sit through a series of meetings and hear speeches and papers by able, thoughtful men and women having no selfish end to gain or commercial purpose to serve is, indeed, a delightful privilege. Such was the privilege that was enjoyed by all who attended the sessions of the Northwest Scientific Association's convention in Spokane last Friday and Saturday.

Assembled there were men and women of keen, analytical and alert minds, educated and trained in scientific channels; whose lives are self-dedicated, not to personal aggrandizement, but to consideration of the finer things in life, to the expansion of the realm of human happiness and the public welfare, servants in development fields striving to better understand and more effectively apply to human progress the laws of Nature.

Without exception, because of the research and experimental character of most of the work they do, they are poorly—inadequately—paid in a cold dollars sense; but they are happy in the pursuit of knowledge and in the enjoyment of propinquity with the mysteries of the universe. And it was truly refreshing to listen to those learned scientists discuss topics directly affecting the lives of all of us, but without a suggestion of finance or money-gain in anything they said. They read their carefully-prepared papers or delivered their scholarly addresses, each with no personal purpose to serve, no selfish ''cause'' to promote, no propaganda to ''put over,'' no thought nor conclusion not directed to or based upon truth, honestly, studiously, conscientiously arrived at.

Attendance at that convention was as helpful to the mind as it was refreshing to the soul.—(R. E. White, Editor of Associated Country Newspapers)

MR. IRVINE FRENCH of Enterprise, Oregon, participated briefly in the discussion of the salmon situation. Mr. French is Superintendent of the Salmon Hatchery at Enterprise. Except for interruptions for college and the World War he has spent his entire life in close contact with the fish migration phenomena as they are presented in Wallowa River and Wallowa Lake. This has given him unusual opportunities for acquaintance with the entire history, by personal observation, of the Sockeye Salmon from the days when runs of ''redfish'' crowded the river to capacity to the present. Until the building of a dam for power and irrigation, Wallowa Lake was one of the principal breeding places for this species. Also, he has made the experiment of hatching eggs of these same ''redfish'' after generations of confinement in the lake, marking them, and liberating them in the river to go to sea, and having a few of them as adults return to their home stream.

Another item which he contributed was concerning what is believed to be the only entirely successful fish screen known. This was built by the farmers at great expense and with volunteer labor. It was placed about 200 yards from the outlet of Wallowa Lake, supported by a great arc of cribs of heavy planking filled with stone. Most of these cribs still are intact. Though a success it was destroyed, it is said, by order of an ill-advised state board.

Research Projects of the United States Bureau of Fisheries in the Northwest

DR. F. A. DAVIDSON
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The fishery resources of the State of Washington support one of its most valuable industries. Although there has been a decline in prices for fish products during the past few years the total yearly values to the fisherman for fish and shellfish have still been close to $5,000,000. Approximately one-fifth of this total value or $1,000,000 annually is contributed by the Columbia River to the Washington fishermen. In addition to its valuable commercial fisheries the State of Washington abounds in rivers and lakes that provide one of the most generous and interesting sport fisheries in the United States. Although the value of this sport fishery connot be measured in terms of dollars and pounds production, the sale of sportsmen's supplies and the returns from tourist traffic amounts to a considerable sum. Furthermore, the recreational value of the game fish resources of the state far transcends the usual monetary standards of value.

The fishery resources of the State of Washington have for years provided bounteous returns to the people engaged in their utilization but unless some adequate provision is made for their protection and conservation they may at any time be easily destroyed through the destruction of their spawning grounds or by unwise exploitation. The fish populations that compose this natural resource are constantly undergoing changes in abundance due in part to variations in the natural elements that influence their survival and in part to the artificial hazards imposed upon them by man. Therefore a rational policy of protection and conservation calls for continuous observation of the fish populations both biological and statistical in order that their numbers may be properly safeguarded and utilized. To this end the U. S. Bureau of Fisheries has offered its services to the State of Washington. It is endeavoring to assist the state in the determination of the causal factors responsible for the fluctuations in the abundance of its fishery resources with the aim of providing for permanent and productive fisheries. It has, however, long been the policy of the Bureau of Fisheries to regard its particular obligations as concerned, first, with interstate and international fishery problems, and second, with local fishery problems of the individual states, the latter being undertaken only as the result of public demand. With this aim in view the Bureau of Fisheries is conducting an investigation of the Columbia River salmon fisheries, the coho salmon fishery in both Washington and Oregon, and the sockeye salmon fishery of Puget Sound, the latter being international in scope.

Program for Study of Columbia River Salmon Fisheries.

The 1934 Congress passed an Emergency Appropriation Act which included provision for a sum of $33,790 to be used by the United States Bureau of Fisheries on the propagation of salmon and trout in the Columbia River Basin. Of this sum $24,140 was apportioned for the carrying on of practical and scientific investigations of the salmon fisheries of the Columbia River and $9,650 was apportioned for repairs and alterations of the Bureau's present salmon hatcheries in the Columbia River district. The sum apportioned for scientific investigations will provide for the continuance and completion of the investi-

gations on the Columbia River that were tentatively discontinued due to lack of funds and also for a comprehensive study of the salmon fisheries in the Columbia River system. A program for this study has been developed and will include three major lines of investigation.

1. **Statistical study of the Columbia River salmon fisheries:** An accurate knowledge of the annual fluctuations in the abundance of the fish populations upon which a commercial fishery is drawing is of primary importance to the proper administration and conservation of the fishery. This is obvious when one considers that such knowledge forms the basis for determining whether the fish populations are decreasing in abundance at such a rate that additional protective measures are needed, or increasing at such a rate that a more intensive fishery may be permitted. In short this knowledge forms the chief index of the status of the fishery. This phase of the work will include the continuance of the statistical analyses of the fluctuations in the abundance of the chinook salmon and blueback salmon in the Columbia River that were tentatively dropped due to the lack of funds. A similar analysis will be made of the fluctuations in the abundance of the other species of salmon composing the Columbia River fishery.

2. **Study of the protection of Migratory Fish at Power Dams and in Irrigation Canals in the Columbia River System:** Any attempt to determine the success of the devices employed for passing the migratory fish over power and irrigation dams must include an accurate count of the fish that pass over the dams each season. This number will vary from year to year and unless it can be definitely shown that these fluctuations are not due to changes in the intensity of the commercial fishery, the success of the migratory fish passing the dams cannot be determined. It is for this reason that the problem of studying the influence of power and irrigation dams on the runs of migratory fish in the river system must of necessity be correlated with a study of the statistical analyses of the fisheries. Provisions are being made for the accurate tallying of the number of migratory fish passing the power and irrigation dams in the entire river system. Careful records will likewise be kept of the ease with which the migratory fish locate the devices and of the mortality of the fish in passing through them.

In eastern Washington and Oregon where water from many tributaries of the Columbia River is diverted for irrigation purposes, there is considerable loss of the young salmon and trout that migrate from the streams into the irrigation canals. The extent of loss due to the passage of young fish into the canals will be determined and suitable devices will be recommended for the screening of the canals and ditches.

3. **Biological Study of the Columbia River Salmon Fisheries:** The Columbia River with its numerous tributaries supports a vast area of gravelly stream beds. These stream beds have in the past formed the spawning grounds for millions of migratory fish. With the development of power dams and irrigation projects in the Columbia River Basin many of these stream beds or spawning grounds have been cut off, with the result that the migratory fish native to them have either perished or been forced to seek new spawning grounds. It is quite probable that many of the spawning streams which are now blocked by artificial obstructions may be restocked with migratory fish and made available to them by the construction of fishways to pass the returning adults over the obstructions or by the artificial propagation of the adults at the obstructions. Hence one of the first steps that will be taken in the study of the biological status of the Columbia River fisheries is to make a thorough and exhaustive survey of the Columbia River and all its tributaries. Each tributary and its branches will be traversed and an accurate record made of the area of spawn-

ing grounds available to migratory fish at the present time and likewise the area which has been cut off by either natural or artificial obstructions. A detailed study will be made of the obstructions in the streams for the purpose of recommending ways and means for the rehabilitation of the unavailable spawning grounds and their utilization by the migratory species of fish. This survey will also provide information upon which recommendations may be based for the purpose of increasing the productivity of the spawning grounds in the streams which are at present available to the migratory fish.

Although the effects of pollution in the Columbia River system have not as yet become acute, with the exception of the pollution of the Willamette River at Portland, there is need to plan for the control of pollution in the future. The development of cheap power on the Columbia River will induce the development of such industries as the manufacture of paper and linen and the smelting of ores, all of which will contribute greatly to the pollution of the waters of this river system.

With the increased use of the Columbia River and its tributaries for water power and irrigation projects, the artificial propagation of the runs of migratory fish in the river system will have to be utilized to a greater and greater extent as a substitute for the natural propagation of the fish. In view of the many purposes for which artificial propagation has been used, it is desirable to point out its proper function in the maintenance and development of the runs of migratory fish in the Columbia River system. The artificial propagation of the runs of migratory fish should not be substituted for the natural propagation of the fish where it is possible to provide for the latter. Artificial propagation should be used only in case of necessity and as an additional means of maintaining or increasing the productivity of the spawning areas. In other words, fish hatcheries should not be operated to intercept runs of fish that can avail themselves of suitable spawning grounds. On the other hand they may be operated very effectively for the purpose of (1) maintaining runs of fish whose spawning grounds have been destroyed or rendered inaccessible, (2) restocking available spawning areas whose native runs have been greatly reduced or depleted, (3) rehabilitation, by transplantation of fish, of unavailable spawning areas whose runs of fish have been exterminated by either natural or artificial obstruction, and (4) increasing the productivity of the river system by establishing artificial runs of fish on tributaries that support no spawning areas.

In order to make efficient use of artificial propagation as a means of maintaining or increasing the productivity of spawning areas, it will be necessary to make a study of the various methods by which artificial propagation of the runs of fish may be carried on. Such a study is of primary importance when artificial propagation is to be used for the purpose of rehabilitating spawning areas by means of restocking them with new species or new races of a species similar to the native species. The hatching and rearing of young fish to the age at which they normally migrate is in most cases very expensive. Hence the cost of hatching and rearing fish for the purpose of transplantation may be greatly reduced if transplantation can be successfully carried on in the earlier stages of development. For example, experiments will be carried on to determine the success and efficiency of (1) transplantation of water hardened eggs (just after fertilization) in the gravel beds on the spawning grounds, (2) transplantion of eyed eggs of young fish in all stages of development from newly hatched fry to fully matured fingerlings ready to go to sea. It might be well to mention that the Canadian biologists have found that the transplantation of eyed eggs in the gravel beds has given very good results and shown possibility of greatly re-

ducing the cost of the artificial propagation of migratory fish.

Coho Salmon Investigation.

The coho or silver salmon runs that enter the coastal and inland waters of the State of Washington provide the basis for a large and valuable sport fishery as well as composing a considerable part of the catches of the commercial fishery. In the fall of 1933 the Bureau of Fisheries started an investigation of the coho salmon fishery in both Washington and Oregon for the purpose of making a thorough study of the life history of this species and the determination of the causal factors responsible for their recent decline in abundance. Particular attention will also be given to the study of the potentialities and development of the coho salmon as a source of supply for the salt water sport fishery.

The life history study that is being carried on at the present time is concerned with the determination of the homing instinct of the salmon or the extent to which the adults return to spawn in their parent streams and the age at which they return to spawn in their parent streams and the age at which they return to spawn, age at maturity. These two phases of the life history of the cohos are of primary importance since it provides a means for determining the individuality of the salmon populations in the various streams along the coast and the length of time it requires for a population to reproduce itself.

Every effort is being made to secure the records of the catches of the coho salmon by the commercial fisheries as far back in point of time as these records are available. A system of recording the catches of cohos by the sport fishermen has also been established. These catch records of the coho salmon by the various methods of fishing will be used to build as complete a picture as possible of the trend in the abundance of the coho salmon that has taken place since the inception of the fishery.

Puget Sound Sockeye Salmon Investigation.

The sockeye salmon fishery in Puget Sound is almost entirely dependent upon the Fraser River for its stock of fish and maintenance. Therefore the present investigation which was started in 1931 deals mainly with that population of fish.

One of the primary objects of this investigation is to compute the relative annual variations in abundance that have occurred in the fishery. This is being done on the basis of catch return per unit of fishing effort and gear. Since the Fraser River run, like all runs of sockeye salmon entering a complicated river system, is composed of several or perhaps many separate populations, each inhabiting a distinct spawning area, it is of importance to determine the individuality of these populations, their state of relative abundance, and time of passage through the commercial fishery, in order that each component of the run may be properly protected and all of the spawning areas used to the fullest extent.

Marking experiments dealing with the mechanics of the homing instinct of these fish and the length of time which they must be held in the waters of streams before they will acquire a homing urge for that stream are being conducted. These factors are of importance when runs of fish are to be transplanted.

This investigation is at present being actively carried on and catch records of all of the salmon fisheries of Puget Sound are being compiled. The Bureau's investigators are cooperating with the British Columbia scientific staff on several phases of this work.

The Effects of Power and Irrigation Projects on the Migratory Fish of the Columbia River

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In early days, before the development and industrialization of the Pacific Northwest, our streams, including the Columbia River, were in a practically virgin state and according to all available evidence supported immense populations of fish. As man put the land and waters of this region to his use, he necessarily brought about many changes and unfortunately the changes wrought by the progress of civilization are rarely beneficial or even compatible with the welfare of our wild life, whether it be birds, fish or mammals. This is necessarily so, when we consider that the fauna of a region is adapted to that particular region in its habits, food and other requirements, so that any significant change will probably react unfavorably to the original inhabitants.

Some examples of industries which change the natural surroundings of our migratory fishes might be briefly mentioned. Logging operations often result in destructive deforestation which removes the cover from along the banks of streams. Lack of shade in some instances causes the temperature of small streams to rise so that they are no longer suitable for salmonoid fishes. Soil erosion sometimes follows removal of the forest cover, which results in the washing out or silting over of spawning gravels. The destruction of natural trees and shrubs along the course of a stream sometimes so changes the habitat of insects, which may be an important part of the food supply of the fish, that they are greatly diminished in numbers. Logs or debris incidental to logging operations may block the migrations of migratory species.

In some instances mines dump refuse products or silt into streams in such quantities that both fish and the organisms on which they feed are destroyed. Industrial and sewage pollution is an important problem near centers of population.

Man's utilization of the fishery resources by capturing the fish, either for profit or pleasure, is undoubtedly in many instances the most important factor in the decrease in numbers of our fish populations.

When the waters of streams are used for power or irrigation developments, we must expect changes in conditions which affect stream life because the water courses which are the home and migration routes of our migratory fishes are altered. Before discussing these changes it might be well to briefly consider the habits and life histories of some of the more important species of migratory fish inhabiting the Columbia River.

The species that are of the most importance are the chinook, silver and blueback or sockeye salmon. The adult chinooks usually deposit their eggs in the gravels of a tributary stream during the late summer or fall. The eggs then develop and the young salmon or fry emerge from the gravel during the latter part of the following winter or spring. Some of the young salmon, notably the offspring of the late-running or "fall" chinooks, migrate at once into the sea. Others spend the entire next summer and winter and part of the following spring in fresh water before migrating. After an ocean residence varying from one to four years, usually two or three years, these fish become mature and seek the fresh water to carry on their spawning activities. Apparently they do not eat, or at least do not digest any food, after entering fresh waters.

After spawning they die and the cycle is then continued from the eggs deposited in the gravel.

The young fish while in fresh water have much the same habits as trout and if they have had one or more years' fresh water residence they are from three to six inches long when they enter the ocean. It is in this habitat where most of their growth is accomplished, since upon maturity they may weigh as much as thirty or forty pounds after two or three years of ocean life.

The life history of the blueback salmon is very similar to that of the chinook, except that these fish almost without exception spawn in tributaries which flow into lakes. The fry after emerging from the gravel go down into the lakes where they carry on their fresh water existence. This species is almost entirely a plankton feeder and subsists upon these small organisms both in the lakes and in the salt water.

The silver salmon have essentially the same life history as the chinooks except that they mature earlier, being largely three years old when returning to spawn. Unfortunately no great amount of research has been done upon this species, so the details of its habits are not as well known as those of the chinooks and bluebacks.

The steelhead trout are another migratory fish of some importance in the Columbia River. They are members of a different genus than the salmon that have been mentioned and feed in fresh water after spawning. It is probable that some of them make their way back into the ocean and return to spawn at least a second time. Except for this difference, they have much the same spawning habits as the chinook salmon.

When chinook and blueback salmon make their spawning migrations, they return with a very small amount of straying to the same stream in which they were hatched or reared. In large river systems such as the Fraser or Columbia, they not only return to that river but to the same tributary where they began their fresh water existence. This habit or instinct for homing divides the run of salmon in any large river system into many different "runs" or races, each of which is self perpetuating and develops different minor characteristics best adapted to the conditions that that particular race encounters. Examples of these racial differences are the variations in fat content at maturity exhibited by different populations of salmon and the differences in the times at which they begin their upstream journeys. It is a general rule that the chinooks and bluebacks, which make the longest migrations, enter the streams the earliest and are the highest in fat content. This is as would be expected since the fish traveling the greater distances must have sufficient time to reach their spawning grounds, which may be several hundred miles from the sea. Also, because of the fact that they do not eat while in fresh water, they must have enough energy in the form of stored fats and proteins to enable them to complete their long journey.

With these facts in mind, we shall now consider how the use of streams for power and irrigation purposes affects these migratory species. We should keep in mind the fact that these streams are not only the home of most of the migratory species but the only means of communication which they have between their fresh and salt water habitats and that both of these environments are essential to the survival of these species.

Dams erected either for power or irrigation purposes probably affect the migratory fishes more directly than any other structures or activities related to these two developments. This is evident when we consider that these structures offer impassable obstacles to fish unless proper protective devices are installed and often change the course or character of streams. Dams may affect a run of fish in any of several ways, according to the degree of efficiency of the facilities

provided for the passage of fish both up and down stream.

If no provision is made for the migration of the adult salmon going upstream to spawn, they are prevented from reaching their spawning grounds. In such a case they will either strive to surmount the barrier until they die without spawning or will spawn in some location in the immediate vicinity, suitable or otherwise. In view of the marked tendency of the chinook and blueback salmon to return to their parent stream, the first alternative is the more probable. Unfortunately in years past this situation has occurred on tributaries of the Columbia which supported runs of blueback salmon. Since these fish must reach tributaries accessable to a lake in order that the young might survive, the runs or races frequenting these tributaries have been wiped out.

Serious results also follow if the provisions made for the upstream passage of the mature adults are so inadequate as to cause a marked delay in their migration. This is evident when we remember that the salmon do not eat while in fresh water and have a limited amount of time and energy available with which to reach their spawning grounds and carry on their reproductive functions. If they are forced to expend a goodly portion of this time and energy in waiting below or attempting to surmount an obstacle, they may be prevented from reaching their parent streams; in which case they may either continue on until they are exhausted or spawn in some strange location. Because of the indifference to difficulties displayed by chinook and blueback salmon when on their spawning migrations, it is probable that most of them would not spawn successfully.

Injuries suffered while leaping at or surmounting obstacles are often serious in many cases. These injuries are also often the origin of infections such as fungus, which may prove fatal to the fish.

Dams sometimes flood spawning areas so that they are no longer suitable, or create large lakes through which the fish may have difficulty in finding their migration routes.

These same dams also present difficulties to the young migrants on their way to the sea. Because of the fact that fishways or passes usually carry such a small volume of water in comparison to that going over a dam or through the power units, most of the young fish go either over the spillways or through the power wheels. In dams where the drop is not extremely high and the volume of water is large, the mortality of fish going over the spillways is usually not high. The damage done by the power wheels varies with their size and speed.

Irrigation projects and sometimes power developments necessitate the diversion of water from natural stream channels. The water used for irrigation flows into fields where it is absorbed or drained off into some location not suitable for fish. If irrigation diversions coming out of streams containing migratory fish are not screened in such a way as to prevent these fish from entering them, much damage will result from the young migrants entering the diversions and becoming stranded in fields or dry ditches. Adult salmon or steelheads migrating upstream are not so apt to enter these diversions, but unscreened diversions are an extremely destructive factor in relation to the young migrants in the upper reaches of the Columbia.

In some instances such a quantity of water is diverted from the natural stream bed that not enough is left for either the up or down stream migrants to pass. Such a situation presents the same difficulties and dangers as an impassable dam, and if allowed to continue will result in the extermination of the fish utilizing the spawning areas above the diversion.

The results of water utilization just described paint a rather discouraging picture in regard to the future welfare of our migratory fishes in the Columbia River. However, progress is being made in devising protection for these species. Efficient and economical screens have been invented

and are being installed in some important diversions and it is hoped that their use will become more widespread in the future. Fishways over dams are being constantly improved and new ideas incorporated in their construction, and methods are being studied for the protection of down stream migrants at power dams and intakes.

Artificial propagation is being called upon to care for runs of fish which are confronted by dams which are so high that the passage of fish over them, either up or down stream, is impracticable. These adult fish can be trapped and spawned artificially below such dams and the young fish either reared and liberated at that location or transferred to some other more suitable place where natural spawning can be carried on by the returning adults.

However, as power and irrigation projects become more numerous, the protection and conservation of the migratory fishes of the Columbia present a problem which requires the best efforts of our engineers and biologists and the cooperation of the state and federal agencies involved, if this resource is to be maintained.

The First Record for the Stomach Nematode *Spiroxys contortus* (Rud.) in Washington Turtles

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Three turtles, *Chrysemys bellii marginata* were collected from Moses Lake (near Neppel, Washington) for parasitological examination. The stomach of one turtle contained five nematodes, all threaded into a single ulcer. Four of these worms were males, the other a female. In the intestine of the same host were four old, limp, dead females which had become detached from the stomach ulcer.

A careful study of these worms while alive and after being preserved and cleared, proved that they were of the species *Spiroxys contortus* (Rudolphi 1819). Firmer confirmation of the identity of these worms was determined by carrying through the early stages of the life history. The details of egg structure, free-living larvae, infection of the cyclops, and development of the larvae to the 2.5 mm. stage were identical to those for the life history of *S. contortus* as reported by the author (1931).

This is the first report of this species from the state of Washington. Previous records for the distribution of *Spiroxys contortus* are: (a) in the European turtle, *Emys orbicularis* ; (b) in turtles from Oklahoma, Harwood (1931); (c) in turtles of Texas, Harwood (1932), and (d) in turtles of Michigan and Wisconsin as determined by myself. These regions are discrete indeed, but plans are being made to continue the examination of turtles from other parts of Washington and even other states in an attempt to determine the correct range of this nematode.

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*Presented before the Botany-Zoology Section of Northwest Scientific Association, Spokane, Washington, December 29, 1934.

SALMON CANNING. On Flathead Lake in Montana, Past President Howard R. Flint found a commercial cannery of landlocked "redfish" when he and Mrs. Flint spent a late autumn vacation on that lake last November.

Some Problems Which Confront the Fishery Experts in the Construction of Dams in the Inland Empire

HENRY O'MALLEY
Former U. S. Commissioner of Fisheries

With the rapid development of our great natural water resources in the Northwest and especially on the Columbia River, the scientist, the engineers and the practical men are met with a challenge that is going to tax them all to their utmost, if we are to save the fish life of the Inland Empire. The first obstruction that the anadromous fishes will meet is at Bonneville, then the Rock Island dam at Wenatchee and finally the major project, the Grand Coulee dam.

Among the problems that must be solved if the Inland Empire is going to have its share of fish life as in the past are: first, the successful passing of the adult fish over the dams; second, getting the little fish and the adult steelheads back to the sea; third, the complex problem that arises from the changed conditions brought about by the dams and artificial lakes.

I have been pleased to see the four commissions controlling the destinies of the commercial and game fishes in the States of Washington and Oregon presenting a united front on the fishway matter as they affect the Bonneville dam. Mr. Tom Lally, Chairman of the Washington Fish and Game Commission, read into the records of the Fisheries Section of the Pacific Northwest Regional Planning Commission, at the meeting recently held in Seattle, a joint resolution covering what at this time they feel is necessary to safeguard the migrating runs of salmon and steelheads, also a provision for the maintenance, care and modifications that may be needed after the dam is completed. Mr. Lally stated that the salmon industry had an annual value of ten million dollars and with the allied industries employs about 20,000 persons. The dam is a relief measure and we all recognize its value from this standpoint. It is estimated the Bonneville dam will cost about $30,000,000, and will give employment to about 5,000 persons during the period of construction. While appreciating the worth of the dam we must not forget the long term value of the salmon industry over a period of years, which makes it necessary for every one of us to do the best he can to protect its future.

The Rock Island dam is completed and the two fishways installed in it are passing the salmon in a satisfactory manner, especially the fishway located on the right limit of the river. The passage of salmon can be further facilitated at this point by the installation of the third fishway on Rock Island that was provided for in the original plans, but the finishing of it was delayed in order that a study might be made, of where the salmon congregate in order to place the down stream outlet at the point where it would best attract the fish.

The next obstruction is the major one, the Grand Coulee dam. If the high dam is built, I understand its elevation will be about 450 feet. That will present a real problem and I have grave doubts as to how successful fish will be in ascending that barrier.

The entire Columbia River watershed may well be confronted with an entirely new biological condition. The series of dams will to some extent impede the rapid flow of the water in the Columbia River and naturally we may expect to see higher temperatures which may not be congenial to the salmon and trout now inhabiting these waters. May not the entire population tend towards the warm water species such as bass, sunfish, suckers and bottom fishes?

The history of artificial lakes developed in New England and elsewhere throughout the United States has been that, during the first years after the lakes are formed, the fish in them grew rapidly and the fishing is excellent, the fish caught

were larger than formerly, and the fishermen become very enthusiastic over the situation. Then without warning the catches taper off rapidly and difficulty is found in even taking small quantities. The increased size of the fish comes, of course, from the large amount of food developed by the overflowing of the virgin lands, but the fishculturist finds difficulty in restocking the lakes. Some of the causes come from the fact that the natural spawning beds have been to a large extent destroyed. These lakes are subjected to a wide range of levels, they are drawn down during the summer months and early fall and filled during the late winter or early spring. This condition causes a barren marginal waste—its size depending upon the fluctuations of the lake. If the fish spawn in the fall their eggs are deposited at the low ebb of water conditions and are deeply submerged when the lake begins to fill. On the other hand, if the fish are spring spawners they will spawn on the marginal areas which will be dried out before the eggs hatch, either case being harmful to the future of the fish needed to stock the lake. In lakes subjected to wide fluctuations the zone that is flooded is parctically without permanent life and is devoid of those permanent growths which in the ordinary shore zones serve as nurseries and food manufacturing areas, for the young fish. It is my understanding that a wide range of levels will not be brought about by the Bonneville and the Rock Island dams, but it will be by the Grand Coulee, and it will affect a vast area as the water of this dam will not only be drawn off for power purposes but also for irrigation if the high dam is constructed, and obviously that is the dam that will be of the greatest service to agriculture. Therefore the spawning of salmon in the fall and the spawning of steelheads and blackspotted trout in the spring, especially of those that spawn in the lake or in the lower reaches of the rivers tributary to the lake, will be affected.

Undoubtedly many of you have had the opportunity of visiting Lake Chelan, where the lake has been raised from 16 to 20 feet by the power dam at its outlet, and had the opportunity of seeing the barren waste that exists there during the summer months. It is this condition magnified, that will exist above the Grand Coulee dam.

Another problem that confronts the fishery expert is the proper screening of the intakes of these power projects and the preventing of millions of all kinds of fish being carried out onto the fields through irrigation ditches. In the past the U. S. Reclamation Bureau has been one of the chief offenders, having built many irrigation projects over the Northwest with utter disregard for the fishes that inhabit the streams that were to be used for irrigation, notwithstanding the many protests from the U. S. Bureau of Fisheries and scientific organizations.

With the building up of the Inland Empire, that will and must come with the water power development, immediate steps should be taken to combat pollution and see that our rivers do not become trade sewers like so many of our once fine eastern rivers. Two shining examples of such polluted streams are the Illinois River and the mighty Mississippi River in which the Keokuk dam has already accumulated behind it a vast mass of sewage and filth which will not only kill off the fish but prevent their replacement until the sludge is removed or modified chemically. It has also been predicted by eminent scientists that the canalization of the Mississippi River will destroy the best bass fishing region in the northern states.

I realize that I have not painted a very optimistic picture but I feel it advisable to call these matters to the attention of this body so that every precaution may be taken to safeguard not only the commercial but the game fishes of the Columbia River watershed and pass them on intact to posterity.

Certainties and Risks Affecting Fisheries Connected With Damming the Columbia River

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The Columbia River has produced more salmon than any other river in the world. It still produces more than any other river. This is the principal basic fact and certainly to be kept in mind when considering the possible effects of any modification of the channels of that river.

The fish of the Columbia River which are important in an economic way are the salmon (using the name collectively for the several species of true salmon which breed in the Columbia and for the steelhead trout), and shad, and sturgeon. The value of shad, sturgeon, and all minor fish caught in the Columbia is small compared to the value of the salmon (only 2.5%). The shad and sturgeon will not be affected by the Bonneville and Coulee dams. Shad remain in the lower Columbia, not ascending the rapids above Bonneville. Sturgeon are found in the upper as well as the lower Columbia and do not migrate regularly. Confining this species to the upper or lower regions of the river will not affect it unless new and unexpected conditions develop. Therefore any immediate problem affecting the fisheries of the Columbia caused by the dams concerns the salmon.

The problem may be stated thus: The Columbia River with its tributary streams, now maintains a large fishery, which gives employment to thousands of men, and produces a surprisingly large income. This is the present certainty. Is it possible that the construction of the Bonneville and Coulee dams will interfere with this fishery to some extent, introducing elements of risk and uncertainty?

Certainly the dams will be barriers to the upstream migration of adult fish on their way to their breeding places; the spillways, and particularly the turbines, will present hazards to the young fish migrating to the sea.

The risk presented by the dams is proportional to the number of salmon which seek the upper Columbia. (By the upper Columbia we mean the part of the river above the Bonneville dam.) We have no exact information about the proportion of Columbia River salmon which migrate into the upper Columbia. That it is large is indicated by the fact that until lately there have been profitable commercial fisheries along the Columbia for 60 miles above Bonneville. These fisheries did not fail, but were closed by popular vote in order to protect the fish in their migration to spawning grounds. Cobb* states that the Columbia River is a typical example of a stream in which considerable salmon fishing is carried on in the headwaters, of which no account is taken in the data of commercial fisheries. "Commercial fishing is usually considered as ending at Celilo. . . . As a matter of fact, salmon fishing for market or for home use is carried on to a considerable extent along the main river and also on the Snake and on the Yakima tributaries of the Columbia. In nearly all cases hook and line and spears are used alone, but on the Snake River, near Lewiston, in Idaho, are several rather important haul-seine fisheries. Fishing is carried on at several places in the spring for steelhead trout and in the fall for chinook and silver salmon and steelhead trout. As many as 25 salmon have been taken at one time. While this may seem a small number to one habituated to the large catches farther down the river, in the aggregate it amounts to a considerable quantity.

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*Cobb, John W.—Pacific Salmon Fisheries: Fisheries Documents No. 1092.

Considerable local fishing is carried on along the various Oregon streams above the sections usually fished by the commercial fishermen. Most of this is done by ranchers living along the streams, and while by far the greater part is for home consumption, a small proportion is sold.'' The important significance of this statement is that it shows that a considerable migration of salmon takes place to the headwaters of the tributaries of the upper Columbia.

It is also well known that large numbers of salmon pass up the Columbia as far as the British Columbia portion of the river. The largest and best of the three annual runs of chinook salmon migrates to the upper Columbia. Salmon are migrating up the Columbia for eight or nine months of the year. An estimate has been made that during a part of the run salmon should pass the Bonneville dam at the rate of 10,000 an hour.

While we do not know what part of the salmon breed above the Bonneville dam site and what part below, it is well recognized that the dam will present an obstacle to an important proportion of the migrating fish.

We are informed that no provision is being made at the Coulee dam for the passing of salmon. It seems probable that the number of salmon reaching this point is comparatively small; yet that is a proportion which will be cut off from natural reproduction.

In this connection it is important to note that various influences may be operating to cause a larger proportion of the salmon to migrate to the upper river than in previous decades. The forests of the coast range are being cut and farms are taking their place in part, causing the small streams of the lower Columbia to become more seasonal in flow, more silt-laden, and warmer. Power dams are cutting off the headwaters of the larger streams. Sewage and industrial waste are polluting increasingly the most important tributaries of the lower Columbia. During the summer months the oxygen content of the Willamette is close to zero for several miles above its junction with the Columbia, and that river is thus effectively closed to the entrance of fish.

It is certain, then, that a large proportion of the Columbia River salmon must pass the Bonneville dam if natural reproduction of the species in its present numbers is to be continued. A serious aspect of the fishery problem is that the means for the fish to pass the dam must be successful from the first. There will be no time for experimentation. If only a small portion of the run crosses the dam and reproduces in the first year after its construction, this fact will not be proven until a reduced run occurs four or five years later, and by that time all the runs will have been reduced similarly. And so far, man has been extremely inefficient in restoring the plenitude of fish which he has destroyed. The risk that the Columbia River fishery will be permanently reduced if provisions for getting the fish past the Bonneville dam are not 100% effective, is a very real and menacing risk.

The plans of the Bonneville dam, as now drawn, show a carefully studied and comprehensive attempt to design a construction which will enable the salmon to pass the dam. The members of the various fishery agencies concerned and the engineers should be given great credit for the plans which have been developed for this purpose. It should be remembered that the dam project was started suddenly, and that appropriations for its construction were based upon a preliminary and incomplete estimate of cost, which did not include nearly enough to pay for the construction of effective passes for fish. Also, that time has not been allowed for the experiments necessary to test the effectiveness in practice of the fish-way devices which have been invented.

Four fish-ladders, and four lifts are planned. These are to be located at the shore ends of the dams across the main river channel and the power house channel,

and from Tanner Creek. It will also be possible for fish to pass through the ship locks. In order to direct fish to the ladders and lifts the engineers have designed a channel across the base of the power house dam which is expected to lead the fish to the lifts and ladders which flank it. Another type of collector for fish will be located at each end of the spillway dam, but these will not reach far into the channel, and can be used only part of the time, at best.

The fish ladders are a type of construction which has been more or less successful on a smaller scale elsewhere, and there is no reason to doubt their usefulness here, **if the fish enter them.** The lifts are experimental structures which have not been tested under any conditions resembling those of the Bonneville dam. What they will accomplish we do not know, but we hope that they will be extraordinarily efficient, because every workable device is going to be needed to maintain the fishery.

We feel that a very great risk exists that many of the salmon will not go to the entrance of the fish ladders. Salmon are directed in their upstream migration both by the strength of the current and by the temperature of the water; particularly by the latter, according to Ward. Observations at other dams have shown that the temperature of the water going over or through the dam is lower than that in the sluices. The water flowing through the Bonneville dam will be deep and swift, drawn from far below the surface, while that going down the fishways will be drawn from the surface of the lake above the dam and will be comparatively shallow. We should expect the water leaving the fish ladders to be noticeably warmer in the summer months than that of the river channels. If this should be the case, will the fish choose to ascend the fish ladders, or will they turn back into the main channels? Experience at the falls of the Willamette at Oregon City has demonstrated that the salmon will remain in the swift water below the outlets of the turbines of the mills rather than follow the weak current leading to the fish ladders. The amount of water going through the dam will be about 1000 times as much as that going down any of the fish ladders, while the main channel of the Columbia River is 30 times the width of a fish ladder.

Perhaps the cross channel designed by the engineers of the dam will be highly successful in leading the salmon to the fish ladders. We hope and wish so. Nevertheless it is experimental; we cannot help being doubtful of its complete success when we remember that our experience with fish has proven that it requires much study and experimentation to learn how fish behave under any set of conditions, and why they do so.

Any interference with the passage of the salmon up the Columbia will result in a reduction of the catch of these fish four or five years later. If the interference continues the reduction will be permanent. That the Bonneville dam will present a serious obstacle to the passage of salmon is certain. The proportion of salmon which will find their way over it is altogether uncertain. We shall hope that all the fish which arrive at the dam will be able to pass and find spawning grounds above. If many do not, the effect on the Columbia River fisheries will be certain and soon felt. The balance of nature is, in the long run, very close; the number of fish which will return to the Columbia in any year will be in a nearly exact proportion to those which have been able to find their spawning grounds in an earlier year.

The lake to be formed above the Bonneville dam will be about 40 miles long. Engineers estimate that the current in the lake will flow at the rate of about six miles per hour. We should not expect the formation of the lake to change the upstream migration of the salmon to any great extent. Two physical effects may be expected from the formation of the lake: sedimentation on its bottom, and submerging of sloughs. We should expect the ef-

fect of sedimentation on fish life to be comparatively little. The sand and silts which will be deposited will contain some coarse organic material which, during its decay, will absorb oxygen from the water. But the nature of the country through which the Columbia flows for 200 miles above the dam, and the small number of towns pouring sewage into it, will probably prevent oxygen absorption being serious. But if large industrial towns later develop between the Coulee and Bonneville dams, sewage and industrial waste carried by the river may increase greatly, with a consequent lowering of the oxygen content of its water.

The submerging of sloughs and shallow ponds communicating with the river may have immediate effects because these are the places in which is produced the greatest quantity of minute animal and plant life which constitutes the primary food of fish. New shallow water areas will, of course, be produced as the lake rises; but the terrain is such that they will be much more limited than those now existing in the narrow flood plain of the river, and they will not immediately become adjusted to the development of plankton. A period of years will be required for the lake to acquire a stable biological balance. The question suggests itself—what will be the effect of a body of water of this size, poor in fish food, upon the young salmon in their down-stream migration?

In the migration of young salmon to the sea the turbines of the power plants present another risk. When all the power units of the Bonneville project are installed and in operation, the entire flow of the river will pass through the turbines, except for the small portion going down the fish ladders, for five months of the year. The only passages for young fish migrating to the ocean and for returning steelhead will then be the fish ladders and the penstocks. It seems inevitable that most of the fish will be drawn into the penstocks during such periods. Those who have handled fish find it hard to believe that the fingerlings can pass through the penstocks without being injured. Even a very slight injury to their delicate skins may eventually cause death.

The type of turbine designed for the Bonneville power plant gives small fish a better chance to pass through uninjured than other types, and experiments made by the U. S. Bureau of Fisheries indicate that young fish may pass them alive (though the reported experiments have not been made with fish). But beneath the turbines the turbulent escaping water will contain numerous small "vacuum pockets" which experiments indicate as serious dangers. So far as true salmon are concerned we have to consider the passage down stream of fingerlings only: i. e., fish 3 to 7 inches long. But adult steelhead return to salt water after spawning, and may ascend streams, spawn, and return to the ocean several times in a lifetime. We can see no chance for a mature steelhead to pass through a turbine alive. And to destroy the returning steelhead in this way must eventually have an effect upon the steelhead fishing above the dam. It does not seem so likely that fingerlings which pass through the main dam will be injured.

But here again the actual effects are not known. Water will pass through the dam at the bottom of the gates, about 60 feet below the surface of the lake, under a hydrostatic pressure of two atmospheres (30 pounds to the square inch), and at an estimated velocity of 60 miles an hour. We do not know how fish will be affected by such conditions.

As the main channel of the Columbia is much wider than the power channel, and also will have the swifter current, it may be expected that most of the young salmon will go along that channel and through the dam during high water periods. Many may even pass down by way of the fish ladders. The plans of the dam include a wing which is intended to direct the fingerlings away from the power channel and into one of the fish ladders. This will

probably be efficacious for those fish which happen to travel in that particular portion of the lake, but it is difficult to think of its having much effect in directing the majority of the young fish, especially when the power house installation is complete.

Another device to save the fingerlings consists of a floating collector on the upstream side of the power dam, intended to direct the fish to a bypass at the shore end of the dam. Similar collectors have been suggested for the main dam, but they can be used only during low water periods, and near the ends of the dam. These devices are entirely experimental and untried.

The value of the Columbia River as a producer of salmon consists of three factors: (1) The value of the salmon taken by the commercial fisheries; (2) the value of the salmon (including steelhead) in sport fishing; (3) the value of the salmon incubated in the Columbia to the marine fisheries along the Pacific Coast.

For the year 1929* the value of commercial fisheries of the Columbia River district, lying in the states of Oregon and Washington was as follows:

Value of catch of salmon and steelhead (amount received by fishermen)	$3,037,374
Value of products manufactured from fish	$9,431,435
Value of fish not included by statistics	471,571
Total value of fish products	$9,903,006
Fishermen employed	4621
Persons employed in wholesale establishments	196
Salaries and wages	$ 212,798
Persons employed in manufacturing establishments	1453
Salaries and wages	$1,272,527
Persons employed in transportation by boat	83

*Fielder, R. H.—Fisheries Industries of the U. S. 1930.

The value of the salmon caught in the Columbia River district of Washington was 13.5% of the total value of the salmon fisheries of the state. In Oregon, the Columbia River district salmon fishery has a value equal to 71% of all the commercial fisheries of the state.

The value of the sport fishing of the Columbia River basin which is furnished by salmon is very difficult to determine. It has been estimated at $10,000,000. This estimate is formed on an entirely different basis from that used for arriving at the value of commercial fishing. The value of sport fishing is based not so much upon the value of the fish caught as upon what is spent in going fishing. We all know that sort of fishing is an excellent method of putting considerable sums of money into circulation. This estimate has been made by those best qualified to do so; yet we feel hesitancy in accepting it as an accurate statement of the income produced by this kind of fishing. The value may be much less—perhaps only half as much as the estimate, but common knowledge of the number of persons whose recreation includes fishing, the number of persons who supply camps and boats, the amount of money spent for fishing tackle, outfits of clothing, transportation, etc., convince us that the total value of this fishing is truly a large one.

The third factor, the value of the Columbia River as an incubator for the marine fisheries, is one to which too little attention has been given. After young salmon leave the river they migrate north and south along the Pacific Coast to great distances. Upon their return, or even during the period of growth, they are caught in large numbers by trollers, purse-seiners, and traps. The trollers may be either commercial or sport fishermen. Seventy-seven per cent of the value of the fisheries of the Pacific Coast of Oregon is furnished by salmon, most of which probably are hatched in the Columbia River. One of our greatest authorities on the life of the salmon has estimated that the

value of Columbia River salmon caught at sea is at least $10,000,000 annually.

The total annual value of the Columbia River salmon fishery, actual and estimated, is, therefore, in round numbers:

Commercial fisheries	$9,900,000
Sport fishing	$5,000,000 to $10,000,000
Marine fishing, incubated in the Columbia	$10,000,000
Total value	$24,000,000 to $29,000,000

The fact is outstanding that whether the estimates of the value of the salmon fisheries of the Columbia River are accurate in detail or not, the value is a large one. In fact, the annual income derived from the fish of the Columbia River is almost as great as the total estimated cost of the Bonneville dam, and many times as much as anyone expects the direct income of the Bonneville dam ever will be. The present value and income of the **fishery** is a certainty.

The information derived from the marking of young salmon gives some evidence, according to Rich and Holmes*, "of the existence of local races in the tributary streams" of the Columbia, which enter the river at definite and characteristic times and tend to return to their own tributary streams to spawn. "Knowing further, that each race is self-propagating, it becomes perfectly apparent that all parts of the salmon run in the Columbia River must be given adequate protection if the run as a whole is to be maintained. The protection of only one or two portions of the run will not be sufficient, inasmuch as certain races will be left entirely unprotected."

The Coulee dam presents itself as an absolute block to the migration of salmon past its location.

Bonneville dam is a great risk to the permanent maintenance of the Columbia River fisheries by natural means. And if it is proposed to maintain the salmon fisheries by artificial means, that is another problem which has not been satisfactorily solved.

It is certain that the dams are not going to do the fisheries any good. Just how much harm they will cause, and what measures may be employed to maintain the fish tribes of the Columbia, we shall know only at some future time.

Summary.

Salmon, including steelhead, produce more than 97% of the value of the Columbia River fisheries. The value of these fisheries consists of three factors: (1) Value of salmon taken by commercial fisheries; (2) value of salmon in sport fishing; (3) value of salmon hatched in the Columbia to Pacific Coast marine fisheries. The total value of these factors, partly known and partly estimated, is $24,000,000 to $29,000,000 annually. Salmon migrate for spawning to the headwaters of the Columbia and its tributaries. Coulee dam will stop such migration to points above it. Bonneville dam will be a barrier to the migration, which may be passed by means of fish ladders and lifts. There is considerable risk that many salmon will not pass the dam by these means, and that the number of fish spawning above the dam will be reduced. For young fish descending the river a risk will exist: (1) In a long lake-like stretch of water above the dam in which the current will be slowed, and which will be poor in fish food; and (2) that a part of them will be drawn through the turbines of the power house. In a fishery of the magnitude of that of the Columbia River great economic loss will result if only a small proportion of the salmon fail to pass the barriers of the dams.

*Rich, W. H. & Holmes, H. B.—Experiments in marking young Chinook Salmon on the Columbia River, 1916-1927. U. S. Fisheries Document No. 1947.

Two Papers

Two papers which were to have been a part of the Symposium failed to materialize. One prepared by Mr. T. B. Murray of the U. S. Biological Survey of Boise, Idaho, on habits of the sturgeon in the Snake River was put in the mails but was not delivered and still remains unaccounted for. It is hoped that it may be found and possibly appear at a later date. The other by Mr. W. B. Weaver of Pasadena Park, Spokane, who was formerly county game commissioner, was not presented because of illness. In an interview, recently, Mr. Weaver gave the reporter the gist of his paper, which is here presented in part.

Mr. Weaver was a pioneer in this region and all of his life he has been an interested observer of natural phenomena. Fish and game have been his hobby. His belief is that in the young of the Pacific lampreys, (*Entosphenus tridentata*) , fish and water-fowl, where these creatures are permitted to migrate up the streams and spawn, have a food resource of untold value. According to his observations, the female produces enormous quantities of small eggs. These are all deposited in one locality in the stream bottom and he has found that the young remain together in very large masses, or balls. Places where he has usually found them have been in deltas where small streams flow into ponds and lakes, in particular in localities of much water vegetation. Here these little "eels" are fed upon, particularly in winter time, by great numbers of birds and by many kinds of fish. The great mass protects those deep in the "ball" where they also seem to thrive and grow faster than those on the outside of the mass.

When time for their seaward migration comes their movement downstream seems to be followed by numbers of birds. Mr. Weaver thinks they remain in the fresh water about three years. Their numbers are being constantly depleted, but the enormous number of eggs hatching is sufficient to maintain the supply of breeding stock.

The upstream migration of the salmon furnishes means of transportation for the lampreys which, by their sucking mouth, are enabled to attach themselves firmly to the bodies of the fish. Dog salmon, in particular, because of their sluggish habits, are most likely to be victimized. However, the lampreys find their way to far-away headwaters. Their migration and breeding times and life history in general correspond very closely to corresponding events in the life of the Chinook salmon. Like the salmon they die after spawning.

This view of Mr. Weaver's concerning the value of these migrants from the sea supplying important food for inland fishes and birds, lights up the whole picture of ecological interrelations of fresh-water life. In general we have thought of them as undesirable members of our aquatic fauna, as being destructive in their blood-thirsty feeding habits. Yet the feeding of the adults is almost entirely in the sea. The young are not blood-feeders and do not begin their seaward migration for several years, feeding and being fed upon, in the muddy and vegetation-crowded bottoms of fresh-water streams and pools. On their return they are able to climb over waterfalls and low dams, but it is probable that most of those which will pass the high dams will be attached to salmon.

As a new and original contribution to science this may or may not take high rank, but as helping to dispel some of the vast and varied ignorance concerning interrelationships of our water creatures Mr. Weaver and other observers like him have nothing to be ashamed of in a scientific gathering.

ABSTRACT OF

"Proposed Methods of Protecting Migratory Fishes at the Bonneville Dam"

By HARLAN B. HOLMES,
Associate Aquatic Biologist, U. S. Bureau of Fisheries

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The Bonneville power and navigation project which will obstruct the main Columbia River at about 150 miles from its mouth, presents the greatest problem of protection to migratory fish ever encountered. As a result of the nature of the obstruction, the tremendous size of the river, and the magnitude, variability and value of the runs of fish, it is necessary to modify conventional means of fish protection and to devise new ones for application to this project. A staff of biologists and engineers representing the state fish and game departments, the U. S. Bureau of Fisheries, and the U. S. Army Engineering Corps have devoted the past year to the study of the problem of fish protection and have designed fishways for use on the project. These fishways consist of modified fish ladders, fishways embodying the principles of a navigation lock, and a new feature known as a "collection system" which is employed to attract and conduct the fish to the base of the fishways.

The problem of the passage of down-stream migrants also has been given careful consideration. Experiments have been conducted, both in the laboratory and in the field, to determine the probability of injury to fingerling fish in passing through the spillway gates. Means of preventing fish from entering the power wheels are being considered and much attention is being given to by-passes for down-stream migrants.

The final plans for fishways have not been approved as yet, but it is anticipated that they will involve four modified fish ladders, two or more pairs of fish locks, three units of "collection systems," and three or more special passes for down-stream migrants. The total cost of these facilities will be between $3,000,000 and $4,000,000.

Mr. Holmes' contribution was presented in the form of a very interesting talk with pasteboard models for demonstration. Time did not permit him to write it and prepare drawings which would properly present it in this issue. It is hoped it may appear in a later issue of Northwest Science.—(Editor)

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NORTHWEST SCIENCE

MAY, 1935

Vol. IX No. 2

Published by

The Northwest Scientific Association

Single Copies Thirty-five Cents

THE
C. M. FASSETT
CO., Inc.
N. 207-11 Wall St., Spokane, Wn.

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Is Entered as Second Class Matter, April 5, 1927, at the Postoffice at Cheney, Washington. Office of Publication, Cheney, Washington. Subscription Price to Members, Including Dues, One Dollar per Year; to Non-Members, One Dollar.
Volumes I. to VIII., 1927 to 1933, Each $1.25.

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-:- EDITORIAL COMMENT -:-

ENDOWMENTS. What will five dollars do for SCIENCE? Buy a book the library cannot afford to own, for a student who is alone, studying a field obscure, but vital to us all. Ten dollars will secure a piece of apparatus which the laboratory budget with not permit, but which is essential to some student's investigation. Twenty dollars will take another to a point in his field of interest where he may collect critical material for completion of his thesis. Forty dollars will support another in laboratory or field for a half of a vacation, for concentration on a process or experiment. Eighty dollars will buy gas and oil for a scientific field party to and from almost any part of this almost wholly unexplored Inland Empire. One hundred dollars will hold some brilliant graduate student for another semester in any college in this section, while five hundred dollars will support a "fellow" for one year in college devoting his entire time to investigation.

Would you gamble on a horse-race or a prize-fight where the only winning is by the other fellow's loss? Then why not try a throw on some bright young scientist? Any well-planned and executed research brings forth some facts of value and many times returns are on the order of a thousand fold. A bright youth with a wise "prof" for a partner makes a winning combination. Our Board of Trustees will make it their business to find the combination for you.

BLESSED ARE THE "DEPRESSED" may be a new beatitude. Four years ago a veteran physician remarked "This depression is ——." Asked if people didn't get sick as much as ever, he said: "No, they don't! They haven't any money so they can't get booze, and they don't go out and fill their bellies with indigestible food. They stay home nights and sleep, and there you are." Science Service quotes learned investigators who have found that serious mental disease is not on the increase. After all man has thrived best on hardship. He was evolving rapidly and quite successfully when civilization overtook him. A look at his foot and leg tells of speed to overtake something or to escape something else. Possibly both. Nimble wit probably has a "survival value," even in more important things than a bridge game. His physical makeup does not particularly adapt him to sitting behind a mahogany desk. Love of adventure may have gotten him in trouble but it also took him to new fields. He was adaptable and has "possessed the earth" more than any other living creature (the mosquito excepted, possibly). . . . Research science was once an adventure and still should be. We are getting into ruts. Sometimes these take form of elaborate equipment and overmuch financial support. Leave applications and gadgets to calculating engineers and puttering inventors. Let the depression drive you back to the wife's kitchen, the woodshed, the shop, the garden, the orchard, the puddles, ponds, creeks and lakes. Too much we are "on the shoulders of giants." See again as did Lieuwenhoek, Franklin, Joseph Henry, Galvani, Priestly, Harvey, Beaumont, Faraday, and Condon. More power to our own George Beck. Only a few years ago he was picking up a few splinters of fossil wood, where now he has forest on forest, at Vantage. Miocene flora and the present day vegetation are, in his work, an unbroken story. Let Bretz leave his frozen and perilous Greenland and return to flabbergast the orthodox geologists with new theories of catcylsms. What thinking our geologists have had to do in the past decade! It is good to be compelled to seek sound basis for any credo. . . . Far Cathay and beyond may be too far for our unfinanced expeditions to seek the "bones of Adam" but Ales Hrdlicka has found his grandson's footprints where he crossed the Behring Sea and he was heading this way. There are plenty of pictured rocks under protecting cliffs from the Little Spokane to far down the Columbia. Hunting the Oreodon, camels, rhinoceros, great trunk turtles and other choice game in the hills of the John Day River Valley should be satisfying to adventurers. The mammouth may be hiding in any (very) old morass between Spokane and Klammath Falls. If puzzles attract, join the group of puzzlers who are trying to find a way to save one great industry while hasty construction hurries to establish another. Indeed the great unknown still presses closely all about. It is not so far away as our fingertips. In a few instances it has been explored and exploited until expensive equipment is needful for further progress. In many cases interest, ingenuity and persistence are more needed. Why should scientists be further depressed? Not Antaeus alone gains strength from contact with Mother Earth.

NORTHWEST SCIENCE

VOL. IX. MAY, 1935 NO. 2

The Association is not responsible, as a body, for the facts and opinions advanced in the papers published by it.

Scientific Relationships in the Life of a Forest

By HOWARD R. FLINT

Address of Retiring President of Northwest Scientific Association December 28, 1934.

The subject is large for a paper of this sort. It is as broad as the horizon, somewhat higher than the length of the tallest eucalyptus, deeper than the root system of the most tenacious desert tree.

There can be no worthwhile discussion of such a topic without a fairly clear definition of the subject. We must limit ourselves in this discussion: first, by some definition of the term "forest," second, to a brief mention of the nature of some of the forest's more important scientific relationships.

What is a forest? It should be simple and easy to decide that. Perhaps not; Webster's Number One definition is "an extensive wood." "A large tract of land covered with trees," "sometimes specifically, a considerable area of land covered with trees of natural growth." Going back to the Latin origin of the word, "**foris** or **foras**," "abroad, out of doors," the same root exactly as our word, "foreign." Webster's definition is pretty good. It is terse. The scope of his best known publication made that necessary.

Why not ask foresters to define it? Quite an idea. We have tried that. The official, "Forest Terminology" compiled by a committee of the Society of American Foresters reads, "In common usage, a large tract of land covered with trees; more exactly, a tract of land, more or less extensive, covered more or less densely with trees of useful character, viewed from the standpoint of economic use and development."[1] That definition is very much "more or less." A report of a committee of the Washington Section of the Society of American Foresters says, "A forest is a biological unit."[2]

All these definitions leave much to the imagination. For the purpose of this discussion, a better one might be: "A forest is a formation of more or less interdependent organisms intimately related to the soil beneath and to the atmosphere above, and characterized by the prevalence of tree species."

This is the sort of a definition of a forest we might well keep in mind while this discussion is in progress. It is only by some such conception that we can appreciate the scope and range of the scientific relationships possible in the life of a forest. Possibly foresters and most botanists are less accustomed than they should be to regard a forest as resembling an individual organism; each tree, shrub, herbaceous plant, fern, moss, fungus, lichen, bacterium, protozoan, worm, mollusc, insect, bird, and mammal with a more or less definite influence on every other part. A complete biota, highly complicated, delicately balanced, easily thrown out of adjustment.

With this preliminary discussion we may consider a few fields of science which are

1. B. E. Fernow. "Forest Terminology." (Journal of Forestry, January, 1817.) p. 77. Society of American Foresters, Washington, D. C.
2. Earl H. Clapp, "A National Program of Forest Research." (The American Tree Association, Washington, D. C., 1926) p. 192.

important in the life of a forest and essential to man's satisfactory management of it.

BOTANY AND TAXONOMY

These are among the earliest efforts of science along forestry lines. Botanists are still learning things about some of our common crop plants which have been under close observation for years. The botany of forest vegetation is still far from complete. Each year new species are being found and the known ranges of old ones are being extended.

PLANT PHYSIOLOGY AND MORPHOLOGY

The knowledge of function and structure is of vast importance, is well advanced for only a few species of our native forest plants. Root forms and habits of mature trees have been too little studied in the forest. Preliminary studies indicate that they may hold important secrets. Why are some species, races, individuals of trees easy prey to disease or insects, others relatively free? Why is the wood of one tree tough, the next one of the same species brash or brittle? Why seed crops some years, not others? Can seed crops be assured when wanted, increased or improved in viability at will by some simple treatment of the parent tree? The answers to some or all of these questions may possibly be found through knowledge of plant physiology and morphology.

ECOLOGY

The knowledge of relationships between an organism and its environment is the basis of most silvicultural practice. A forest is profoundly influenced by its environment. For most forest species, plant and animal, the various influences are only a little known. Many persons overlook the equally important fact that the environment is also profoundly influenced by the forest. We know quite a lot about that but not nearly enough. A contemporary example is the shelter-belt controversy. The so-called shelter-belt project has developed an informal National debating society, neither side much burdened with facts on which to base their arguments. It will take years to get the kind of facts that are needed. In the meantime it is probable that costly mistakes will be made. The next five years might well be spent in a thorough preliminary survey of the possibilities and a research into so ambitious a program before it is actually undertaken.

GENETICS

Several years ago through the Eddy Tree Breeding Institute in this country and through other agencies, an initial attack was made on the subject of forest tree genetics. Some of this work has since been discontinued. Fruit trees, ornamental plants, agricultural crops, live stock, have all been vastly improved for human use by selection, hybridization and breeding. Is it probable that nothing can be done to improve forest plants, in the forest environment, for the uses of man? Here is a promising field of vast extent which calls for vision, skill, time, and patience in its culture. It will, of course, be almost inextricably interwoven with botany, plant physiology, morphology and ecology and will make many heavy demands on those sciences.

PATHOLOGY

The pathology of forest trees is already a science of fairly long standing in which many able workers have been engaged. This does not mean that the task is nearly completed. The problem is a most intricate one closely interwoven with all of the other biological sciences of the forest. In the long run it will call into play the available knowledge of all these sciences and cry for more. Effective plant quarantine work to prevent entry or spread of dangerous diseases has its foundation on knowledge and application of plant pathology.

Examples of the need for a thorough knowledge of plant pathology are readily available. I may cite the effects of the chestnut blight, an introduced disease, which in about 25 years has almost removed a valuable and important native tree species from this continent. Another case along parallel lines, is the introduced white pine blister rust which in our own locality menaces the continued existence of one of our most valuable commercial tree species and is now involving the attention of hundreds of men and will require a few millions of dollars for primary control. Control of it would be wholly impossible without scientific knowledge of the complicated life history of the disease, knowledge gained only through years of patient study and experiment.

ENTOMOLOGY

At least one able student has characterized insects as man's most dangerous competitor. There is much to support his contention. Insects do not compete with forests but they do compete actively and aggressively with man in the harvest and use of forest products. From formation of a new tree embryo through its entire life history and beyond into man's fabricated wood product the tree and the wood are beset by a legion of insects nearly every one of which is detrimental to the tree's reproduction, growth or continued life. During twenty-ifve years a tiny beetle a quarter inch long, *Dendroctonus monticolae*, has baffled earnest and vigorous efforts of foresters and entomolcgists to prevent him from harvesting millions of thrifty appearing pine trees before we can convert them to human use. Today we frankly admit that we are unable to hold him in check because we don't know enough. Through long ages this insect has been harvesting pine trees. Next summer his children will kill millions of pine trees in Montana and Idaho while our children are enjoying their summer vacations.

I could go on and cite a half-dozen examples of serious insect damage to forests, all presumably controllable if we knew enough about the insect, the tree, and the habitat, to guide us to effective procedure. These examples are sufficient to indicate relationships between trees and insects in the forest to warrant a great deal of scientific endeavor.

ZOOLOGY

Since the forest as a whole includes among its components millions of animal organisms ranging through most of the classification from Protozoans to Mammals there are endless relationships revealed only by Zoology. Directly or indirectly plants, among them many trees, furnish food for the entire animal kingdom. Proper adjustment between the animal and its food supply is essential to the fullest forest development. Beside their service to man a number of forest animals confer direct benefits to trees. Certain burrowing rodents play an important part in soil tillage, some are known effectively to plant tree seeds through peculiarities of their food habits, other animals wild and domestic, are destructive of important forest growth and are, therefore, to be kept in check. The preservation of a proper balance between trees, destructive mammals and the predators which are a convenient and effective means of holding the destroyers in check while at the same time producing valuable crops of fur form a neat problem which is still far from complete solution. Then, there are the diseases of wild and domestic forest animals, some of them transmissable directly to man.

In some areas in this region where the wood-tick is a carrier of spotted fever to man, the more or less complete destruction of both forest cover and animals has been advocated. Science is pointing hopefully toward a vaccine to prevent the disease in man without disturbing the forest. Here is a field of zoological research far removed from the forest yet

treating of an intimate scientific relationship with forest life and with human life.

Some birds, feeding largely on insects, are highly beneficial to tree life, a few are enemies. These relationships are important but not fully known.

BACTERIOLOGY

Bacteria form some of the most intimate relationships known in nature with higher plant forms. Consider for example, the fixation in the soil of nitrogen, an important plant food element, by certain colonies of bacteria which grow in nature only in close relationship with the roots of higher plants. This is only one of the best known of a long list of bacterial activities which are of the utmost importance in the life of a forest. Some bacteria are highly beneficial, others are in like degree detrimental to the life of a forest.

SOIL SCIENCE

A polyglot of zoology, bacteriology, chemistry, physics and other sciences. A new field of knowledge just beginning to receive close study in its wholly vital relationships to the life of any forest. It is now known that the soil in the broad sense of the term is not wholly inanimate but teems with microscopic life and, is thus truly a part of the life of the forest, action and reaction between soil and the forest as we have defined it being profound and intricate.

METEOROLOGY

Land economists some years ago adopted the slogan, "Under all, the land." Meteorologists might well have retorted, "Over all, the weather." Without suitable climatic and weather conditions no forest exists regardless of other factors. Twenty-five years ago controversy was hot between foresters and meteorologists over the influence of forests on weather, climate, and stream flow. It is almost as lively today. The existing scientific relationships are not yet at all well understood and the data to which we can turn for the whole truth have not yet been collected.

Forest fires, the forest scourge preeminent in this part of the world, are almost wholly governed by climatic and weather conditions. Only in very recent years has the science of meteorology been brought to bear on the problem of preventing and controlling forest fires. The relationship is now fully recognized to such an extent that meteorology has actually gone back into the most remote mountain glens to lend yeomen aid in the stupendous task of controlling forest fires.

Weather conditions dictate also, how artificial reforestation must be undertaken and what time or times of year it must be done. In the main it is rain water, or lack of it, and temperature which decides the species of trees, the kind of forest we may hope to produce in any given locality.

The existence of relationships between meteorological factors and forest life is indisputable.

PHYSICS

The science of physics has identified itself with the life of forests in may ways. For example, it offers the best known explanation of how the sap of trees rises from the roots, where the water content is absorbed, to the topmost leaf of trees which may be 200 feet or more in height.

Light and heat are physical forces which exert profound influences on the life of all forests. Without light no green plant can long survive because light is the primary force in the elaboration of food materials. The succession of plant species which will take place when forest growth starts to reclaim a denuded area of soil is, in the long run, determined by infinitely fine gradations and adjustments in the amount and quality of light which filters through the leaf canopy of mature trees and reaches the seedlings

which must sooner or later replace the patriarch which now dominates the lesser life of the forest.

Heat, coming from the same source of light, is often a primary factor in determining the range of species. Excessive heat and inequalities in the distribution of heat are largely responsible for the winds which cause excessive transpiration and evaporation in the forest; killing millions of tiny seedlings preparing the fuel for disastrous forest fires, lowering the resistance of the forest to many other enemies.

CHEMISTRY

The science which is magic, is actively engaged in all vital processes and is invisibly active in every living organism in the forest. It does not stop with the end of life but is active in the decay of forest detritus and in the evolution and maintenance of both the organic and inorganic elements of forest soils.

Man in his control and management of forests makes little conscious use of physics and chemistry. He is beginning to call on them more freely. He uses them widely in the fabrication of forest products but that is another story which would also dwell on mathematics, economics, and sociology.

GEOLOGY AND PHYSIOGRAPHY

These two related sciences exerting their influence largely, but not solely through the forest soil, of which rock is the basis, have more to do with the life of a forest than is commonly realized. In the Big Belt Mountains in Montana one may pass abruptly from a forest dominated by lodgepole pine into one of Douglas fir. The reason, in this instance, for the abrupt change in forest type appears to be in the underlying rock, a granite under the pine, limestone under the fir forest.

Slope, the result of geologic factors often determines species. The same flora and fauna seldom dominates both a northerly and a southerly slope, or an easterly and westerly slope in the mountains. Remove the influence of geology and physiography and uniformity and monotony become much more prevalent.

High mountain ranges, the Cascades and the Rockies, for example, form barriers which limit the range of species and varieties of both plant and animal life and thus determine, to a considerable extent, the type of forest which may prevail over vast areas.

We have attempted here to outline briefly a few of the most important and vital scientific relationships in the life of a forest, to illustrate the relationships by a few common examples, to indicate why foresters are truly interested in science, and, most important of all, to lead more of those who are engaged in scientific work to give the forest the benefits of some of their efforts.

Dr. Henry B. Ward, Permanent Secretary of the American Association for the Advancement of Science and one of America's ablest zoologists, makes the following statement in personal correspondence, after reading a copy of the last issue of Northwest Science:

"I have read with intense interest the various contributions on the salmon and the Columbia River project.

"The Northwest Scientific Association is doing splendid work in focusing its attention upon the outstanding problems of the Inland Empire. There is no one of them that demands prompter and more intensive study than this question of the salmon in the Columbia. Unless all aspects of the question are given serious attention that leads to prompt action, this magnificent natural resource will in a few years be as much a matter of history as the dodo."

Primary Considerations in Developing New Wheats in Washington[1]

By E. F. GAINES

Cerealist, Washington Agricultural Experiment Station

Introduction

For a third of a century the Washington Agricultural Experiment Station has had as one of its major projects the improvement of farm crops through the introduction of new varieties, through the selection of new strains arising in the country by mutation or natural crossing, and through the process of combining the desirable characters of different varieties by hybridization. Since wheat is the chief cereal of Washington, more time and energy has been spent in developing and testing strains of this than all the other crops put together.

History of Wheat Improvement at the Washington Station

Forty years ago, according to Spillman[2], the price of wheat at Pullman was 18 cents per bushel. The year before, the farmers of eastern Washington had lost much of their crop by untimely rains. In 1895 the price rose to 25 cents. There was, thus, a period of three years when the farmers produced wheat at a loss. W. J. Spillman, the pioneer in crop improvement in Washington, took up his duties as Professor of Agriculture at the State College July 1, 1894. The farmers were in distress and turned to the College for help. Spillman suggested diversification of crops and an increase in livestock for temporary relief, but pointed out that eastern Washington was one of the great wheat regions of the world and wheat would continue to be the principal money crop of the average farmer.

At this time the principal wheats grown were Little Club in the Palouse country, Bluestem in the Big Bend, and Red Chaff in the transition zone between, since it yielded more than Little Club and stood up better than Bluestem in this particular region. All three are spring wheats, but were often sown in the fall because of the larger yield obtained from fall sowing. Unfortunately, they were not winter-hardy and would freeze out about half of the time and would have to be reseeded in the spring. There was therefore an urgent demand for a wheat that was hardy enough to withstand the winter.

A collection of winter wheats were tested at Pullman and some of them found to be prolific, but all were easily shattered and had weak straw.

In 1899 Spillman attempted to combine the good characters of the best winter and spring wheats by hybridization. He was eminently successful, and ten years later the now famous club hybrids were in the hands of the farmers. Perhaps the most popular one was Hybrid 128, which at its peak in 1918 to 1925 represented from 10 to 20 per cent of all wheat grown in the State. Others of importance were Hybrid 123, Hybrid 143, and Hybrid 63.

Curiously enough, of all the different wheats hybridized very few were sufficiently prepotent to produce descendants with survival value in the competition of the variety tests. Little Club was the only spring wheat that could transmit prolificacy, stiff straw, and non-shatterability. Red Chaff and Bluestem were used in the crosses with the winter wheats and hundreds of resulting hybrids were tested but none were saved for commercial distribution.

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1. Published as Scientific Paper No. 293, College of Agriculture and Experiment Station, State College of Washington. Presented at the annual meeting of the Pacific Northwest Section of the American Association of Cereal Chemists, June 14-16, 1934.
2. Spillman, W. J. 1909. The hybrid wheats. Wash. Bul. 89, pp. 1-28.

Similarly, many winter wheats were used as parents but Jones Fife transmitted the winterhardiness that made white Hybrid 128 and red Hybrid 123 popular in so many communities. White Track and Turkey were two other winter parents that had some merit. Hybrid 143 is the result of a cross between White Track and Little Club, but it has lost out again and again in competition with Hybrid 128. Barbee's last compilation[1] shows an average spread of four bushels between them during the years 1926 to 1932 at Pullman. Turkey crossed on Little Club gave us Hybrid 63, which for a long time was grown extensively in the Walla Walla country for fall sowing, and grown to some extent in the Palouse country as a spring wheat. It is not winterhardy enough for fall sowing and not prolific enough for a spring wheat in competition with Baart or Federation.

Claude Lawrence, who followed Professor Spillman, selected and distributed several other wheats of hybrid origin in 1907 and 1908, but only the four mentioned above ever reached the 1,000,000-bushel production class in any one year, until Triplet was put out to farmers in 1918.

In the meantime Red Russian and Fortyfold had become established in the Palouse country and Jones Fife and Turkey were generally grown in the Big Bend in years favorable for winter wheat production. Jenkin was becoming common in the foothills of the Thatuna Hills and the Blue Mountains. Baart was rapidly replacing Bluestem in the drier areas. Triplet was increasing rapidly in the Palouse country and in the intermediate wheat areas south of the Snake River toward Walla Walla. It replaced Red Russian on many farms as well as some of the Spillman hybrids. It also encroached on the Fortyfold and Turkey territories. Winterhardiness and higher yield than other winter wheats combined with better test weight were its chief virtues. On the other hand, it was susceptible to smut and had the objectionable hairy chaff which made it unpopular with the harvest crew.

By 1925 the original objects in wheat improvement had been pretty well realized. The winter varieties were winterhardy and had stiff straw in areas where lodging was common. Turkey, which had weak straw, was grown for the most part on the lighter, drier soil here lodging seldom is serious. Most varieties were resistant to shattering except Red Chaff and Fortyfold, and this defect was partly responsible for their decline in recent years. The average yield was improved since that was the final survival test.

In the meantime stinking smut was becoming more and more of a problem. New strains of smut had been introduced following the war, and even the Turkey and Kharkof strains were smutting badly. A larger percentage of car lots at the terminals were grading smutty and the dockage was becoming more severe. How to combat the smut menace was the chief problem under discussion at the annuai conventions of growers, shippers, and millers as far back as 1912.

In 1915 a definite program of breeding for smut resistance was begun at the Washington Agricultural Experiment Station. Many varieties were collected from this country and abroad and tests made by blackening the seed with smut and sowing at the time of year designed to give maximum infection. Hundreds of varieties were susceptible, but a few showed a greater or lesser degree of resistance. The more resistant ones were crossed and the mode of inheritance of resistance was studied in later generations. A cross between Turkey and Florence showed transgressive inheritance. Offspring were isolated that bred true for greater resistance as well as greater susceptibility than either parent. The factors for resistance in Turkey were different from those in Florence, and when

1. Barbee, O. E. 1933. A comparison of wheat varieties in eastern Washington. Wash. Bul. 289, pp. 1-44.

they were all combined in a hybrid segregate they were cumulative in effect, conferring immunity on the strain possessing them. Conversely, the hybrid segregate possessing no factor for resistance from either Turkey or Florence would be as susceptible to smut as any of the common varieties.

One of the 172 hybrid families in the third generation was winterhardy, smut-free, had a beautiful large plump kernel, and in subsequent years the yield proved satisfactory. And so it was increased and distributed to farmers under the name Ridit. In 1926 it was registered with the Bureau of Plant Industry of the U. S. D. A. and the American Society of Agronomy as No. 248. In a survey[1] of wheat varieties made in the Census year 1929 it was found that Ridit represented 16 per cent of all winter wheat grown in the State.

Ridit's resistance to smut is its chief attribute. True, it does not shatter easily, and under proper climatic conditions is an excellent bread wheat, is a fair yielder, quite winterhardy, and fairly stiff-strawed, but its fame as a wheat that will seldom produce smut is known the world over. It has been used as a parent for breeding smut-resistant varieties in Russia, Germany, Great Britain, Australia, Argentine, India—in fact in all the important wheat-producing countries.

The trade at first objected strenuously to Ridit on the ground that it was unknown and would have to be sold on the basis of feed. However, it soon vindicated itself and was selling equally with or above other Hard Red Winter Wheats.

In the meantime, attempts were being made to develop a white-grained club wheat resistant to smut, to take the place of the susceptible Hybrid 128. There was a place for a low gluten, white club type in the export trade, and many crosses were made, and literally thousands of hybrid selections tested before a satisfactory individual was found. Albit is a selection from a cross made in 1920 between White Odessa and Hybrid 128. It was registered in October, 1927, with the American Society of Agronomy and the Bureau of Plant Industry as No. 258. Distributed first in pound lots to farmers in the fall of 1926, it proved so satisfactory because of its resistance to smut that it became the principal winter wheat of the Palouse country within five years. This year, 1934, there will probably be more than 15,000,000 bushels of Albit harvested in eastern Washington and northern Idaho. Albit has all the desirable characteristics that Spillman sought in the old days, namely, winter hardiness, stiff straw, non-shatterability, and good yield. The market demand is similar to that of Hybrid 128 and Jenkin. It threshes free of white caps, which gives it a distinct advantage over Hybrid 128. But the most important factor in its popularity among the farmers was its smut resistance. One farmer's story may well illustrate this point. He said, "If it hadn't been for Albit, I wouldn't be farming today. The last four years I have grown Albit, and have never had less than 40 bushels per acre, and each year it graded No. 1 and no smut dockage. I used to grow Hybrid 128, but it was always smutty. The last year I grew it the field looked like a 40-bushel crop, but I got only 28, on account of smut. Then I took a 12-cent smut dockage on top of that."

However, Albit has probably reached its greatest popularity, and may be expected to pass out as rapidly as it came in, for there are new physiologic forms of smut that attack it almost as severely as the old smut form attacked Hybrid 128, although it has maintained its immunity from the old smut biotypes during the 10 years it has been tested.

Work in Progress.

The building of new wheats is a continuous process, for new conditions re-

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1. Gaines, E. F. and Schafer, E. G. 1932. Adaption of wheat varieties in the Pacific Northwest. Northwest Science 5: 98-107.

quire different emphasis. Just as the coming of the tractor with its greater power and speed makes possible the plowing under of a six-foot sweet clover crop that could not have been handled satisfactorily with horses, so the coming of a new disease or the change in the fertility of the soil may require a different variety of wheat to meet the new conditions. One additional favorable characteristic may be the determining factor. For instance, the coming in of Federation was due to its short, stiff straw and non-shattering glumes, quite as much as to its superior yield. Baart replaced spring Bluestem in the Big Bend country because of its drought resistance in spite of its weak straw and objectionable beards. Turkey, with weak straw and beards, has become the principal winter wheat of the drier areas for the same reason. The value of these two wheats would not have been discovered in the tests at Pullman because with 20 inches of rainfall they are not superior. To meet this problem the experimental work has been expanded in cooperation with the U. S. D. A. to include varietal trials in the principal wheat-growing districts of the country. B. B. Bayles is the coordinating agent for the Office of Cereal Crops and Diseases. His report[1] covers 12 experiment stations, and uniform nurseries at 17 locations for winter wheats and a similar number for spring wheats, five of which are under irrigation. Milling and baking determinations are made under the direction of C. C. Fifield at the Federal laboratories at Washington, D. C. Altogether, some 40 workers in the eight Western States contribute to the cooperative enterprise. Several different varieties are required to meet the special requirements of climatic and soil variations. The main problem is to get the best varieties for a particular community planted and discourage the production of inferior sorts.

In the State of Washington there are six main varietal nurseries and many smaller testing plots run in cooperation with county agents, Smith-Hughes high school teachers, and progressive farmers.

The main station at Pullman does most of the breeding work, tests new introductions from other states and foreign countries, and distributes to farmers the seed of the superior strains. The branch stations also distribute seed of the varieties adapted to their particular sections and sometimes assist in the breeding and selecting program when it is advantageous to do so. For example, at Lind, where the rainfall is less than 10 inches annually, it is customary to test hybrids of wheats carrying desirable characteristics for the dry lands. These hybrids are made at Pullman and grown there through the first and second generations, then sent to the Lind station for testing and selecting in the third and later generations. This year two crosses were sent to Lind for the F_2 segregation. The same rule apples for the Prosser station where spring grains are tested under irrigation. The final selection of a variety must be made in the environment in which it is to be grown.

The winter parents that are most often used in crossing during the past years are those showing the highest degree of resistance to bunt combined with other favorable characters. They include mostly complex hybrids such as Jenkin x Ridit, Baart x Ridit, Marquis x Florence, Turkey x Florence, Albit x Turkey, Turkey x Hohenheimer, Ridit x Hohenheimer, and Oro x Ridit. These are crossed among themselves and out-crossed with the susceptible varieties that are unusually strong in some particular character such as early maturity, high test weight, especially high or low gluten content, and large yielding capacity. These susceptible varieties include the three Federations, Hard, White, and common; Hindi, for high yield and

1. Bayles, B. B. 1934. Results from cooperative wheat varietal experiments in the western region in 1933 with averages for 1931 to 1933. Mimeographed report, pp. 1-76.

short straw; Karun for high test weight; Onas for wide adaptability, stiff straw, and good yield; and Baart for drought resistance.

Plans for the Future.

With more men working on the wheat improvement program and a larger choice of the varietal characteristics from large importations of foreign wheats it is hoped that new varieties that will bring more dollars per acre to the producer for the energy expended will be forthcoming from time to time. Some of the factors such as smut resistance, non-shatterability, and winterhardiness, are factors in the nature of insurance against loss during unfavorable weather conditions or disease epidemics. Other factors such as superior yield, high test weight per bushel, and high gluten content promise more dollars per acre in yield and price.

It will be noted that very little emphasis has been placed on the quality of wheat. There are two reasons for this. The first is there is no satisfactory measure of quality adapted to measuring differences in individual plants. The second is there is no market standard of quality that insures a differential price to producers one year with another. With the changing demands and the changing food habits of the people it seems now that the farmers might reasonably expect a premium for a very low protein wheat as well as for high protein wheat. In the future it is expected that it will be the rule to have greater standardization in the requirements of bakers, and with the coming of the dough ball method of testing it is feasible to analyze more accurately smaller samples in the early stages of selection.

The plant breeder needs the cooperation of the grain trade for foreign as well as domestic demands and also in developing the plant characteristics which will please the farmers and return the greatest profit for minimum investment of capital and labor. The new wheat must be adapted for handling with modern machinery. It must have resistance to the major diseases as well as protection from losses through climatic vagaries, such as winterhardiness, non-shatterability, and stiff straw.

Summary and Conclusions

Since the first cargo of wheat was shipped from Vancouver more than 100 years ago the varieties of wheat grown in the Northwest have been under constant change. This is to be expected in a new country that has been developed largely within the last 50 years. Improvement of the varieties grown came about first through trial and error among the farmers, aided later by the experiment stations under Federal and State assistance. The outstanding improvements have been in, first, greater winter hardiness; second, stiffer straw; third, higher yielding ability; fourth, non-shattering chaff; fifth, smut resistance. Other factors have been emphasized in certain restricted areas such as wheats particularly adapted to escape frost and hot winds. A system of breeding, testing, increasing, and distributing has been worked out whereby the improved strains may quickly become the predominating wheats of the land. Thus within the last ten years Albit has become the leading winter wheat and Federation the leading spring wheat in large sections of the western territory. Early Baart has become the leading dry land spring wheat. Turkey is the predominating winter wheat in the drier areas. Dicklow, Federation and Jenkin have become chief wheats under irrigation.

The primary considerations in building wheats for the future will give greater emphasis to disease resistance and quality, at the same time maintaining the other characteristics that insure against loss and promise greater value per acre.

Jones, J. S. and Colver, C. W. 1916. Dry-farmed and irrigated wheat. Idaho Bul. 88, pp. 1-20.

Schafer, E. G. and Gaines, E. F. 1928. A wheat variety survey in Washington. Jour. Amer. Agron. 20: 171-181.

Some Notes on an Ancient Culture of the Provo-Salt Lake Region

By ALBERT B. REAGAN

Whitney states that Escalante was told by the Utes at Utah Lake in 1776 that about Salt Lake, as we now call that body of water, "The Puaguampe dwelt in little houses of grass and bark; and that these people were sorcerers, 'a numerous nation,' speaking the language of, but not otherwise emulating the hostile comanches."[1]

While the above is probably not a very accurate description of the Indians who occupied the Salt Lake region in Escalante's time and who occasionally warred on the Utes about Utah Lake and had done so for ages past, it gives us the first notice of them and that they were a different people from the Utes, also giving us some idea of the kind of houses they lived in. That they were of the Shoshonean family we are sure and that they were of the Shoshonean division of that family we are almost certain; but whether they are the people referred to below is as yet conjectural.

On the Utah Lake front a mile north of the mouth of Provo River, and a dozen other locations along the lake, a mile lakeward from the usual shore line, the area being left high and dry due to the excessive drouth of this year and the pumping of water over the divide to the Salt Lake section for irrigation purposes, the writer found crude pottery which is neither Basket-Maker nor Puebloan. Associated with this were Shoshonean type arrow points, and Shoshonean type metates, along with mullers (the metates lacking the characteristic double depression of the "Utah" type). He also examined the Bunnell and several other collections from the lake front and finds that they carry similar artifacts. A mound 130 by 95 feet in area on the Rollins Property, east of the lake, about a mile south of the Center (Provo) street road, also contains similar pottery. The pottery here resembles Shoshonean pottery, closely resembling that found in the caves about Great Salt Lake, which Steward says is probably early Shoshonean[2], dating back apparently to some time in Basket-Maker times, he stating in a later article that "this lake pottery is of a pottery culture without horticulture which is probably early Shoshonean."[3] Harrington's Paiute ware from the Virgin River, Nevada,[4] seems possibly to represent this same culture.

In digging in the mounds of the Utah and Salt Lake sections and occasionally on the shores of the former lake and also in the caves of the latter region, one occasionally comes upon a skeleton whose head is not shaped like that of a Ute or a Pueblo, besides the skull bones are thicker. These skulls are undeformed, are long and have high orbits, occipital bulges and strong supraorbitual ridges, all of which are somewhat characteristic of our Shoshones, these characteristics being intensified in the earlier skulls, leading toward the Neandertal type, one such skull cap being described by Dr. Hansen from the Utah Lake front as follows:

"This skull cap, which was found on the Lake front of Utah Lake, is entirely different from those found in the mounds along the lake shore. It is dolichocephalic in contrast to the typically brachycephalic ones of the mounds and of the local Indians. The brain case is reasonably thick with a somewhat unusual supraorbitual development. . . . From the standpoint of physical measurements, it approaches the upper range of Neandertal possibilities."[5]

Besides the above, the writer and his advanced archaeological class at Brigham Young University, at Provo, Utah, have been examining the pictographs of the

lake regions. These are very crude compared with those of the Uintah Basin area, all so far seen antedating the coming of the Europeans. Goats and sheep are shown and also typical Basket Maker, both pictographic and petroglyphic, triangular-shaped drawings of humans often even showing the characteristic side-locked hair, as the hair was worn by that people. While along with these drawings, are drawings of humans in dancing attire which seem to be just as old, drawings which are not drawn by the triangular-bodied pattern, but, instead, depict even strenuous action. Another noticeable thing about these drawings is that they are all above the Provo level of Lake Bonneville, though there is ample opportunity now in the region where they were drawn for them to have been drawn on rock faces at lower levels. A case is that of the petroglyphs just below an ancient cave at Lincoln Beach, southwest of Utah Lake. The boulders are covered with glyphs to the Provo level line which here is very distinct. The drawings are on boulders and while these same boulders extend down the slope to the present lake level, not a glyph is to be found on a boulder there below the Provo level line. If this should prove to be the case all the way around former Lake Bonneville, and it does along practically half of the south side of that lake which we have

Characteristic drawings herewith are:

A war bonnett (No. 2).

Ball jugglers (5 and 33).

A warrior (6).

Goats or antelope (7, 11, 21, 25, 31 and 50).

An eagle or the mythical thunderbird (9).

Other birds (3 and 25).

Dancing men (8A, 10, 14 and 19).

13 and 23), made according to the Basket Maker style of drawing humans.

A snake and a skunk (in 27).

Men (in 20 and various other groups).

Women dancing, showing side-locked hair of the Basket Maker style (32).

Sun drawings (16, 24, 40, 41, 30, 44).

A stalk of corn (28).

A rain cloud and mountains (35), and so on.

now examined, it would mean that a primitive people occupied the area when the lake was at the Provo level which would place their living in the region ten thousand or more years ago, or we will have to revise our estimate of the age of this lake stage. It should be added here that the caves of the Salt Lake area also seem to show that they were occupied by man during one of the interglacial periods and that he was flooded out and the caves silted-in during a later ice-glacial advance, conditions yet to be verified by later research..

The evidence so far obtained indicates that the region of these lakes was first occupied by a long-headed people, either of the Shoshonean family, or a people closely related to them in what we now term Basket Maker II times, some of these having crania leading toward the Neandertal type. Furthermore, as they possessed side-notched projectile points, rabbit skin blankets and long rabbit nets, one might conclude that their culture was a phase of the Basket Maker culture of their time, and as the modern Shoshone also possesses these as well as certain other Basket Maker traits, it is here suggested they might have descended from the ancient Basket Makers, through these peoples, whom I will here term "the people of the Utah Lake culture," Dr. Hansen having termed his find, above, "A Utah Lake Man of archaic type."

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2. Steward, Julian H. Early Inhabitants of Utah, University of Utah Press, Part 1—Mounds and House Types, p. 17, Salt Lake City, 1933.
3. Archaeological Problems of the Northern Periphery of the Southwest. Museum of Northern Arizona Publications, Bull. 5, p. 20.
4. Harrington, M. R. A Primitive City in Nevada. American Anthropologist, vol. 24, pp. 262-267.
5. Hansen, George H. Utah Lake Skull Cap. American Anthropologist, vol. 36, No. 3, pp. 431-433, July-September, 1934.

REED COLLEGE SENIOR MAJORS of the department of biology do research. Seven are carrying on studies in embryology of the sea cat fish and of the Pacific lamprey. One has been making observation of a fresh water Hydroid. The following are their names and the titles of their research:

Miss Jean Ager—The structure of the thyroid gland of *Chimaera collei*.

Miss Frances Bagley—The structure of the auditory apparatus of *C. collei*.

Miss Agnes Burt—Origin and development of the cranial nerves of *Entosphenus tridentatus*.

Richard Lawford—The occurrence of *Microhydra* in the Portland region, and observations on its habits.

Miss Myrta Movius—Structures of the sensory canals of *C. collei*.

Abe Puziss—The development of the eye in *E. tridentatus*.

Excursions. From the Normal School at Cheney, Washington, in a four-day Fourth of July vacation they will accompany Dr. O. W. Freeman to visit Grand Coulee, the Dam and Lake Chelan. That's something, but, when the summer term ends they will go for a two weeks' trip down the Cascades from Mt. Rainier to Lassen's Peak. Worthwhile teacher-training to see three national parks, twenty or more high peaks, the Columbia Gorge, perhaps the Bonneville Dam, and a real live volcano through scientific eyes!

The April, 1935, issue of ECONOMIC GEOGRAPHY carries a well written and finely illustrated article on the "Salmon Fisheries of the Pacific Coast" by Dr. Otis W. Freeman.

OBITUARIES

DR. CARL L. VON ENDE

Northwest Scientific Association and scientific research in the Northwest suffers a grievous loss in the death of Dr. von Ende of the Chemistry Department of the University of Idaho, and member of the Board of Trustees of the Northwest Association. His fine personality and scholarly tastes have left a deep impression on all with whom he came in contact. The article appearing in this issue of Northwest Science on "Research in Chemistry at the University of Idaho" is a testimonial to his energy in building a strong research spirit in a small university. One of his associates sends the following:

The death of Professor Carl L. von Ende on October 9, 1934, removes from the ranks of the university a notable figure. Professor von Ende was born in Burlington, Iowa, July 2, 1870. After attending the local schools, he entered the University of Iowa, taking his Bachelor's degree in 1893 and his Master's degree in 1894. Subsequently he served as demonstrator in the Medical School at the University of Iowa; as a teacher of science in the high school at Burlington, Iowa; returning to the University of Iowa as instructor in Chemistry. In 1897 he went to Germany for graduate study in Physical Chemistry and took his Doctor of Philosophy degree at the University of Gottingen in 1899. Returning to the University of Iowa, he was on the staff of the Department of Chemistry until 1907, when he was granted a leave of absence to engage in further post-graduate study at the Massachusetts Institute of Technology.

In 1908 Dr. von Ende was called to the University of Idaho as professor and head of the Department of Chemistry, where he continued in active service almost to the day of his death. To Dr. von Ende must go the credit for the creation of the present Department of Chemistry at the University of Idaho. He succeeded in building up the department to its present standard of effectiveness and high scholarship standards in spite of the lack of funds and some opposition to his high scholarship standards. Always a gentleman, always a supporter of what he thought was right, Dr. von Ende was certain of the unquestioning loyalty of his friends and the respect of his opponents. In spite of his heavy teaching and administrative duties, Dr. von Ende found time to develop a taste in books and build up a library particularly rich in material dealing with certain periods of English Literature. The University of Idaho will greatly miss him as a counsellor, scholar, and man.

WILLIAM DAVID VINCENT

Born Macon, Mo., December 3, 1866; Died Spokane, Wash., March 1, 1935.

Best known as a banker because of his long service with the Old National Bank and Union Trust company of Spokane, of which he was vice chairman of the board at the time of his death—a service that dates back to 1891 and carried him from assistant cashier to president—W. D. Vincent had a wide range of activities outside finance. In fact, it is doubtful if any resident of the Pacific Northwest was actively interested in as many things as Mr. Vincent.

With but little formal education, he possessed the natural aptitudes of the student and spent virtually all his leisure time in the study of subjects that attracted his interest. One of his early interests was fingerprinting in its early days. He was among the first to advocate its use

in the identification of depositors and saw his recommendations adopted by large financial institutions of the world.

He became an authority on Pacific Northwestern history and collected one of the finest historical collections in the Northwest, never overlooking an opportunity to look up the original sources. Many of his old books are valuable to both collectors and historians.

He wrote pamphlets on Northwestern incidents based on his original research. These were published by Washington State college at Pullman, where many of his historical books now are reposing. Because of his work, that institution at its June commencement has plans for posthumous recognition of his work. By reason of his contribution to Northwest Americana, he was made an honorary trustee of the Northwest Scientific Association.

His literary aspirations brought him into contact, through personal meetings and through correspondence, with many literary notables of his day. One hobby was the collection of autographed copies of first editions. Among such books on his shelves are those written by George Ber nard Shaw, Joseph Conrad, Rudyard Kipling, Otis Skinner and Sir James M. Barrie.

In 1892, commissioned by the Chicago Columbian Exposition to take charge of the exhibit for Labrador, he went to England to make arrangements and then visited Labrador, where, with the help of Sir Wilfred Grenfell, he brought an Eskimo village to the World's Fair. As a result of that experience, he maintained through his life a keen interest in Labrador and established a life-long friendship with Sir Wilfred. His interest prompted him to make a collection of Eskimo arts and crafts, which he presented to Washington State College.

His interests extended to Spokane's Chinese colony, where he was friend and adviser of many of the residents. His home was filled with presents given him by his grateful Chinese friends.

In his chosen profession—banking—he was the recipient of many honors. He had served as president of the Spokane Clearing House Association, of the Washington State Bankers' Association and on committees of the American Bankers' Association.

Mr. Vincent is survived by his widow, Neen McVay Vincent, and two children, Allen, who has won fame on the Broadway stage and in Hollywood pictures, and Mrs. Clifford C. Cowin, Cleveland, O. His first wife was Mary Allen Speidel, Aurora, Ill., whom he married at Wallace, Idaho, in 1898. She died in 1907.

Throughout his life, Mr. Vincent was devoted to the stage and to music and actively sponsored local movements to present worthy attractions in both fields. He was an ardent fisherman and knew intimately most of the fishing streams and lakes of the Pacific Northwest.

DOCTOR CHARLES H. CLAPP

Throughout the Northwest newspaper announcements have before this brought to the membership of Northwest Scientific Association the first sad shock of the news that death, in the early morning of May 9, claimed Doctor Charles Horace Clapp, fellow-member, charter member, former president, councilor and active leader in our organization; personally known to practically the entire membership, admired by all who came in contact with him, and warmly loved by the large circle of those who were so fortunate as to be more intimately associated with him in any part of his remarkably broad field of friendships and interests.

Known in this region since 1916 when

he became professor of geology at Montana State School of Mines at Butte, Montana, Doctor Clapp rose soon to positions of leadership, becoming president of the School of Mines in 1918 and president of the Montana State University at Missoula in 1921. The latter post he filled with rare accomplishment and credit to the time of his last illness. Outstanding features of his administration have been progressiveness, tolerance, elevation of educational standards. In addition to ably directing the course of the University of Montana through eventful years of growth, political strife, and economic crisis, ample work for any man, Doctor Clapp found time for many other important and constructive tasks. He took an active and always a constructive part in shaping a state law creating the Montana Bureau of Mines and Metallurgy, and in legislation affecting both common school and higher education in Montana. Valuable geological publications and maps bear his signature and reflect his thorough and careful scientific research. He conducted studies in the cost of public school and institutional education which brought him wide recognition as an authority on that subject. For a number of years before his death he was Montana's only member and representative in the Geological Society of America. For two years he was president of the Montana Society of Engineers and long an active member in that organization and in the American Institute of Mining and Metallurgical Engineers. He was, from its beginning and up to the time of his death, a member of the Council of Northwest Scientific Association and was its president during 1928.

Space available here does not permit a recitation of more than a few of his more formally recognized achievements. Long and splendid as that list is, his finest achievements, those as leader, guide, teacher, will be known only to those individual workers who received inspiration and courage under his direction and to hundreds of students who owe some of the best things in their lives to his wise and kindly counsel.

Like many another, Doctor Clapp achieved modest fame and a lasting record of accomplishment in the fields of science and education. Among the membership of the Northwest Scientific Association he will be more tenderly remembered for his admirable human qualities, his capable and always constructive leadership and his kindly genial personality. Memory of him will continue to be an inspiration to the fortunate ones who came within his field of influence.

Born in Boston, Massachusetts, in 1883, grandson of a former president of Yale University, Doctor Clapp turned naturally and effectively to the field of science and education, graduated from Massachusetts Institute of Technology in 1905 and later took a master's degree in geology from that institution. Married in 1911 to Mary R. Brennan, his home life was a most happy and fortunate one. Mary Brennan Clapp and eight children survive to carry forward the fine traditions of a life too brief but splendidly lived.

—H. R. F.

A trench dug across the campus of Alaska University at Fairbanks yielded a large number of stone implements and artifacts which seem closely connected with the stone age culture of Central Asia. It has been stated that this seems to place early human invasion of America about 12,000 years ago.

Summer meetings of the American Association for Advancement of Science are being held in Minneapolis and Los Angeles this year.

The Adsorption of Oxygen by Iron

By L. S. KEYSER and WM. H. CONE
Chemistry Department, The University of Idaho, Moscow, Idaho

The problem under consideration arose as a result of investigations of the phenomenon of the passivity of iron. Data showing the adsorption of oxygen by iron was desired in this connection. A thorough literature search, however, failed to bring to light any of the material that was wanted and so the present work was started. Although much work has been and is being done in the general field of adsorption of gases by various metals, no one has treated the particular combination of oxygen and iron.

More specifically stated the purpose of this study was to determine the adsorption, if any, of oxygen by iron under various pressures and temperatures, namely pressures from 0 to atmospheric and temperatures of —20 degrees Centigrade, 0 and 25. In order to carry out these determinations it was first necessary to design and construct the apparatus. After considerable difficulty both in the construction and in learning to operate the apparatus a set-up patterned after that shown by Benton and White[1] was used. The present apparatus has been considerably modified from that of Benton and White, so that perhaps a description of it would not be out of place.

Referring to figure 1. A is a water jacketed burette having a three way stopcock at D. This stopcock allows the admission of the gas to the burette and its subsequent delivery to the adsorption chamber N. B is an open tube manometer for measuring the pressure of the gas in A. The reservoir at I allows the admission of a measured amount of gas from the burette at A to the adsorption chamber. The closed tube manometer at C gives the pressures necessary for the calculation of the amount of gas in the adsorption chamber at any particular time. The difference between the amount admitted and the amount calculated to be present in the adsorption bulb gives the amount adsorbed. The leveling bulbs at L and E serve to raise and lower the mercury in their various systems. F is a distribution system which, with the proper arrangement of stopcocks, allows either air pressure or vacuum to be applied to the leveling bulbs.

The stopcock at M connects the apparatus to a Toepler pump. A Toepler pump is used for two reasons. First, it allows the collection and measurement of the gases pumped off, and second, it furnishes a means of obtaining a fairly high vacuum and thereby insuring a fairly complete evacuation of the gas in the adsorption chamber.

The construction of the Toepler pump now in use is also unique and is worthy of consideration. Essentially this pump is like all other pumps of this type. However, it differs in that instead of the conventional leveling bulb for the raising and lowering of the mercury, air pressure is used. By the use of air pressure not only is the tediousness of raising and lowering some ten odd pounds of mercury eliminated, but also the danger of hammering of the mercury is minimized to the point that an inexperienced operator can use the pump. A diagram of the pumping system is shown in figure 2. The burette at A allows the collection and measurement of the gas pumped off, while the return system at B allows the mercury that is driven from the bulb C through the pump and down the fall tube to the vessel D to flow back to the bulb C. The return system also acts as a constant leveling device for the mercury in the vessel D. Having a constant level at

1. Benton and White. J. A. C. S. 52, 2325 (1930).

E facilitates the determination of the pressure in the burette and thereby the volume of gas which has been pumped from the adsorption chamber.

In operating the pump air pressure is applied through the stopcock at G. The mercury rises and is stopped at F by the ground glass valve. The gas in the bulb I is forced out through the fall tube and is caught in the burette at A. The stopcock G is now reversed and the mercury falls, leaving the bulb I evacuated until gas from the remainder of the system rushes in through F. Repeated strokes of the pump eventually complete the evacuation. The stopcock at H acts as a needle valve for controlling the air pressure applied to the bulb C. This control prevents the hammering of the mercury at the top of the stroke and causes the mercury to flow slowly and evenly.

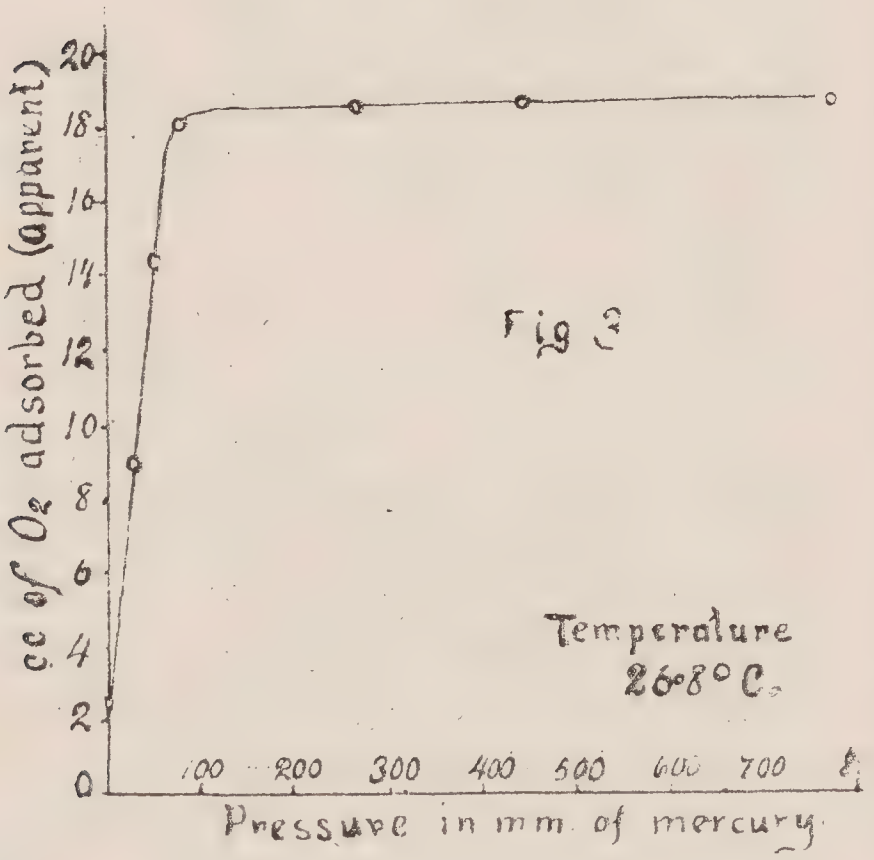


Fig 3

The actual determination of an isotherm consists simply in measuring the adsorption at various pressures. In a run a series of small admissions are made and the amounts adsorbed are calculated from the manometer readings and the volume of the dead space or free space in the adsorption chamber N. (The mercury level in I is always brought to the point K before pressure readings are made). After each run the gas is pumped from the adsorption chamber and measured to find how much of the gas has reacted and how much has been adsorbed only.

The dead space was determined by the use of nitrogen which as shown by Benton[1] is but slightly adsorbed even at 0 degrees Centigrade. The oxygen used in this work was prepared by the decomposition of pure $KClO_3$ in an air tight system. The gas was collected and stored in a gasometer constructed from two 2½ liter bottles. The gas was passed through a drying system before being admitted to the apparatus.

The iron used was prepared by the further reduction of a sample of J. T. Baker's C. P. Iron Powder, Reduced by Hydrogen. This treatment consisted of passing a slow stream of hydrogen through the iron held at a temperature of about 300 degrees Centigrade. This gave a very active sample of iron. Fifty gram samples were used in all runs.

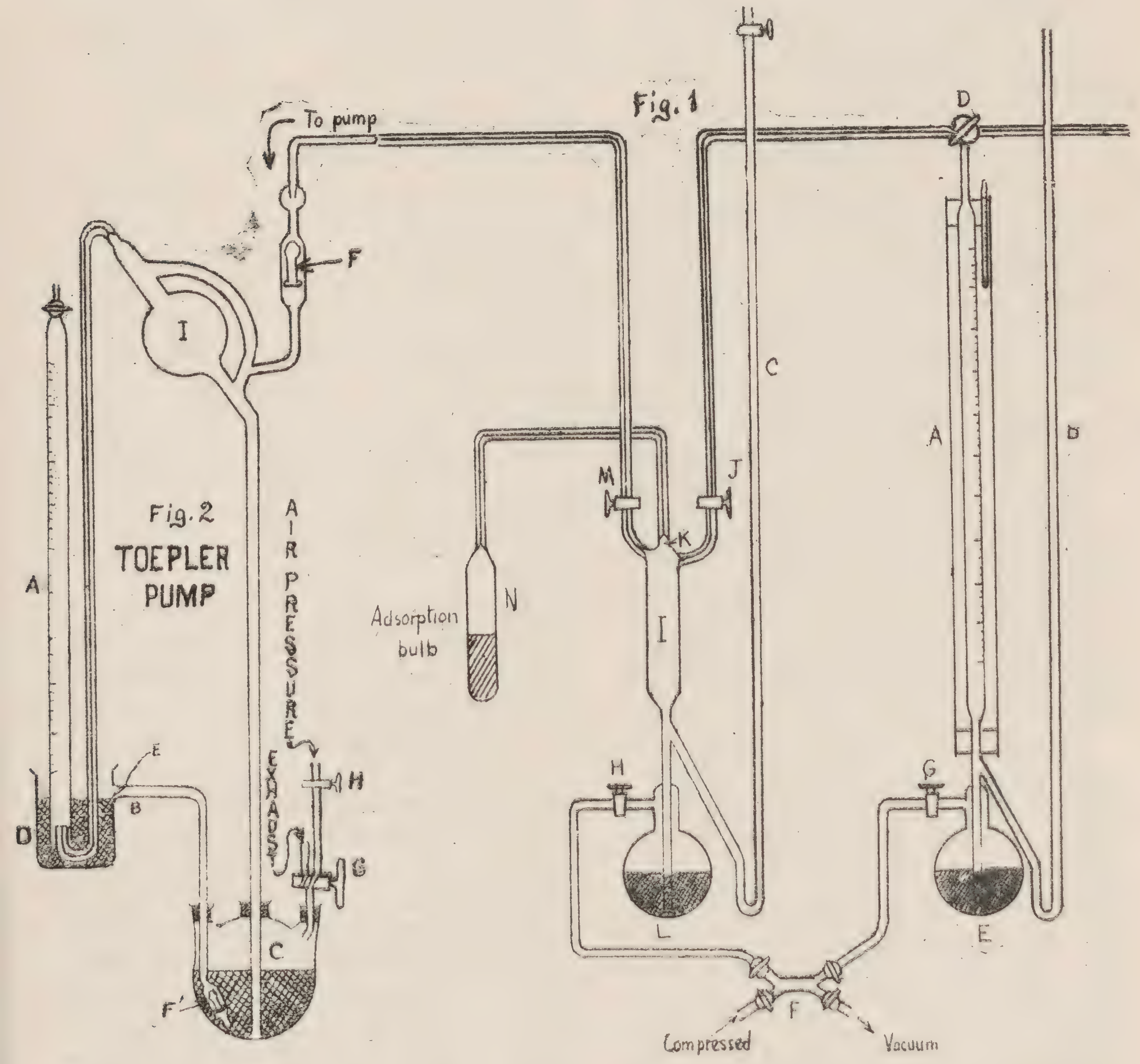
Experimental Results.

The results obtained with varying samples of iron showed the same type of reaction although individual values for the various runs were not identical. This, however, is what one could expect from the nature of the reaction indicated so that the results are none the less significant. The results of all the runs made can be illustrated by a single example. Figure 3 is a typical case showing the isotherm for 26.8 degrees Centigrade with a limiting pressure of about 800 millimeters. The isotherms for other samples of iron and others of the same sample are identical in form and vary only in the initial and final amounts taken up. These varying amounts seem to be a function of the activity of the iron and its previous history.

Benton[2] distinguishes between two

1. Benton, Trans. Far. Soc. "Symposium on Adsorption of Gases by Solids" (1932).
2. Benton. J. A. C. S. 45, 887-9 (1923).

types of adsorption, namely "physical," the so-called van der Waal's type, and "activated," the so-called secondary type. He and others have shown that the physical adsorption is a function of the



pressure and temperature for a given sample of adsorbent and is easily and entirely reversible; whereas, the activated adsorption is of a different nature and is very difficultly reversible. Both of these types are however distinguished from chemical reaction. A first glance at the iron-oxygen isotherms would indicate that the nature of this reaction is that of physical adsorption; however, when the fact is considered that this action is almost entirely irreversible, it seems that the action is not an adsorption at all, but rather a chemical reaction, namely oxidation. Attempts to pump off the gas taken up by the various samples of iron were unsuccessful except for very small amounts. By heating the adsorbent to 400 degrees Centigrade amounts of

about .5 to 1.0 cubic centimeters were obtained in each case. These results indicate that, in the case of the samples of iron used, the adsorption is very small and is of the activated type.

Summary.

An apparatus for the measurement of the adsorption of gases by finely divided solids is described, and the method of operation is explained.

A Toepler pump using compressed air for operation is described.

The interaction of oxygen with finely divided iron is discussed and experimental results are described which indicate that the adsorption of oxygen by iron is small (.5 to 1.0 cubic centimeters for a fifty gram sample of iron at a pressure of about 800 mm.) and is of the activated type.

Chemical Research at Idaho University

A number of very interesting research projects are being carried on by chemistry and chemical engineering students with members of the Chemistry Department staff. Mr. James Pence and Mr. Alonzo W. Martin are extending the work on mucic acid, which Mr. Martin has been investigating for several years, to other organic dibasic acids. They hope to find additional fundamental data which can be used to solve the problem of separating organic acids found in several of the process industries, particularly those dealing with wood conversion. They have just completed the construction of a precision alternating current bridge for conductance measurements.

Professor W. H. Cone is continuing his experiments on the effect of adsorbed gases on the passivity of iron, nickle, and cobalt. Associated with him in these studies is Mr. Lademora, who is measuring the effect of polyvalent irons on the rate of dissolution of ferric hydroxide sols. Mr. John Torgeson is determining the adsorption of hydrogen sulfide by metallic sulfides. Charles Dickerson is studying the factors which cause corrosion in iron. Mr. Louis S. Keyser is continuing the work begun last year, of measuring the amounts of adsobed oxygen held by finely divided iron at temperatures 25 degrees below zero Centigrade. Mr. Renfrew is continuing his measurements of the cataphoretic velocity of nickle sulfide particles.

Robert Haller, with Professor D. D. DuSault, is trying to devise a more workable method for the detection of cobalt. Professor Klug has initiated a series of studies leading up to a better understanding of the molecular structure and properties of crystals. Charles Crowley is investigating the warming and cooling curves of nitrates, looking for evidence of the rotation of the nitrate groups. Kenneth Kirkpatrick is studying methods for the production of single crystals of phosphorus pentachloride suitable for use in crystal structure studies.

Mr. Taylor is continuing his study of the influence of gases on the stability and electrical nature of colloids. In addition, he is interesting himself in the relationship between vapor pressure and dehydration of some of the unstable salt hydrates, and in the process of solution. Associated with Mr. Taylor in these studies are: Gordon Langford, who is trying to find a series of stable liquid soaps with an ammonium base; Branch Walker, who is determining the solubility of the sparingly soluble algaline earth salts in various solvents, by polarographic methods; Wayne Johnson, who is making a phase rule study of the miscibility of some of the common oils in alcohol in an attempt to find the influence of free acids on emulsification and solution.

In the absence of Mr. Turinsky, who is at Princeton University on leave, research problems in Organic Chemistry are being directed by Professor Cady and Mr. Taylor. Mr. Raymond Lundquist is

collecting data which will make the methods of identifying organic compounds more available to industrial laboratories. Stephen Riordan is preparing a number of amino ethers.

Professor Cady is continuing his analytical research and is attempting to extend the application of a method for determining capillary structure recently developed by him. Mr. Robert Harris is studying the capillary structure of cement. Mr. Clyde Snyder is measuring the capillary dimensions of a silica gel by two methods in an attempt to gain an insight into the relation between structure and absorptive power. Bruno Orlandini is measuring the refractive index of varying concentrations of several non-polar organic solutions as the initial step in a further investigation of wood structure.

Mr. Charles Moser is gathering further data on a new method designed to allow an accurate titration of mucic acid in the presence of large amounts of oxalic acid. Martell Harris is studying the precipitation of manganese dioxide in the electrolysis of zinc. These investigations are also being carried out under Professor Cady's supervision.

COLLEGE NOTES

The following research is in progress in the Botany Department of the University of Idaho:

Physiological study of the abnormal hypertrophied region in the upper extremity of the root of **Pinus ponderosa** as related to O_2 and CO_2.—Floyd W. Gail.

Physical-chemical properties of dye stuffs as related to the ascension in plants. —Clair L. Worley.

Drs. F. W. Gail and Vada Allen are preparing a manual of Pteridophytes and Spermatophytes of Idaho.

At the Agricultural Experiment Station of the University of Idaho a series of 131 research projects are in progress in twelve different departments of the station. A staff of forty-eight members is carrying out this work at the station and at several sub-stations. These projects cover a wide range of subjects of interest to the agriculturists of Idaho. In the past year, a bulletin entitled "Science Aids the Farmer of Idaho" was issued, discussing in a very readable form more than 100 topics of importance to Idaho farmers.

The Department of Zoology reports:

H. B. Stough—Cytological (Cell Division) Neurological.

H. B. Stough and H. W. Steffens—Cytological and Neurological.

Louis D. Smith—Irradiation and Cell Division.

Kenneth D. Orr—Cytology of Developing Chick Digestive System.

Maurine Peterson—Cytology of Regeneration in the Earthworm.

L. C. Glass—Genetical (Asymmetry in Rat).

During the past months a group of Reed College professors and students, and members of the Portland community, who are interested in the Bonneville Dam project, has held eight meetings in an attempt to learn **facts** pertaining to the economic effects and possibilities which the dam may produce.

Among those who have appeared in this round table discussion are: Mr. Berkey from the Crown-Willamette Pulp and Paper Company, Mr. Lewis of the Oregon Bonneville Commission, Dr. Loderwich of the Forest Experiment Station, Professor Powers of the Oregon State College, Colonel Robbins of the United States Engineers Corps, Mr. Yeon of the Columbia Gorge Committee, Mr. Merwin, general manager of the Portland Electric Power Company, and Mr. Harlan B. Holmes of the U. S. Fish Commission. Mr. Holmes explained the intricate details of the fish locks and ladders, and discussed the factors which effect migration of the salmon past the dam.

At a later meeting, it is planned that

Mr. Wisting will summarize the results of the Northwest Regional Conference at Seattle, and Marshal Dana will speak concerning the proposed Columbia Valley Authority.

At Washington State College the following investigations will be in progress:

H. V. Carpenter, Dean of College of Mechanic Arts and Engineering—Directing investigations of power consuming industries for Northwest Resources Board.

Homer J. Dana, Asst. Director of Engineering, Experiment Station—Developing heat storage device in the W. S. C. laboratory at Grand Coulee Dam Site for domestic electric heating with off-peak power. Also studies of summer air conditioning.

P. A. Anderson, Head of Physics Department—Investigation of the contact differences of potential between metals.

G. E. Thornton, Mechanical Engineering—Investigation of new industries for the State Planning Council.

S. T. Stephenson, Physics Department—Investigation of fine structure in x-ray absorption edges.

K. E. Fitzsimmons, Physics Department—Investigations in electron optics and some of its practical applications.

Dr. R. F. MacLennan, assistant professor of zoology at the State College of Washington, has received a grant from the A. A. A. S. for the study of Ichthyophthirius, a parasite of fish.

Mr. J. F. Gates Clarke, instructor in zoology, State College of Washington, will conduct extensive field exploration on Microlepidoptera of the Pacific Northwest in connection with revisionary work for the U. S. National Museum.

Dr. Ralph L. Lupher of the geology department of the State College of Washington has been steadily adding to the vertebrate collections of the college. He and his students have found several vertebrae and leg bones of an elephant near the surface of a small alluviated valley eight miles southwest of Washtucna (in Franklin County), and with the cooperation of Mr. A. R. Watzke of Lacrosse, has collected and preserved a large set of bones of the buffalo which once roamed the region. These last were found in the valley fill of Willow Creek, near Pampa.

The new chemistry building on the State College of Washington campus is rapidly nearing completion, and will be ready for use at the beginning of the college year.

Mr. George Van Vleet, Jr., instructor in zoology, W. S. C., will continue his studies in fresh water biology of Eastern Washington.

The construction of the new biological building at the State College of Washington, which is expected to be ready for use in September, 1935, aside from providing greatly needed space for work in bacteriology, botany and zoology, will make possible safe and adequate housing for the botanical and entomological collections. These collections are the most extensive and valuable collections of their kind. Containing as they do, many types of specimens, their preservation from fire or other hazard is a matter of first rate importance to scientists throughout the United States and is of very special importance to workers in the Pacific Northwest.

Dr. Willis H. Rich discusses the salmon situation on the Columbia River in the National Waltonian in an interesting article entitled "Water Power or Salmon on the Columbia?" Dr. Rich feels that the fishways planned for the Bonneville Dam are a magnificent piece of experimentation but that its success is problematical. He concludes by saying, "I have only praise for the scientists of the United States Bureau of Fisheries who have done so well in the face of what must have been discouraging odds. They have tackled the problem intelligently and, if they fail, no discredit should fall upon them. And if they succeed they will have provided our generation with one of the outstanding achievements in conservation."

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NORTHWEST SCIENCE

SEPTEMBER, 1935

Vol. IX No. 3

SEP 1 1935
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-:- NORTHWEST SCIENCE -:-

A scientific journal devoted to the dissemination of scientific knowledge and encouragement of research in the Pacific Northwest

PUBLISHED QUARTERLY BY

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NORTHWEST SCIENCE

Is Entered as Second Class Matter, April 5, 1927, at the Postoffice at Cheney, Washington. Office of Publication, Cheney, Washington. Subscription Price to Members, Including Dues, One Dollar per Year; to Non-Members, One Dollar.
Volumes I. to VIII., 1927 to 1933, Each $1.25.

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-:- *EDITORIAL COMMENT* -:-

DREAMS COME TRUE—Good news for Northwest researchers. A RESEARCH FUND! Chairman B. E. Livingstone, Academy Relations Committee, American Association for Advancement of Science, writes: "... recent action of ... A. A. A. S. gives to each affiliated academy organization which has not been receiving an annual allowance from the Association ... an allotment of funds for research grants. It is expected that this privilege will be extended for future years. The ... allotment is to amount to that multiple of $25.00 which equals, or is nearest above, the sum computed by allowing 50 cents on account of any paid-up" local member "who is also a paid-up Association member." Each organization "receiving an allotment is to name one or more of its members, whether enrolled in the A. A. A. S. or not, to receive from the A. A. A. S. a grant (or grants), in aid of scientific work, and to be disbursed by the A. A. A. S. treasurer." ... Our Board of Trustees is awaiting such an opportunity; our organization, as a non-profit corporation under the laws of Washington, is prepared for exactly this contingency. Secretary Freeman has furnished the necessary membership list. President Rockie has announced his intention of seeking further funds from members and friends. Immediately on making the announcement three contributions of $25.00 each were received. This should amount to a neat sum for this year's work. A word to the wise: Get your applications in to Mr. Weidman, Chairman of the Board of Trustees, early.

EDITORIAL CARPING. Everybody concedes that Science has given the world about all of the physical wealth that makes life worth living, excepting of course, sunshine, air, water and earth (adding when we feel good-natured, our inheritance of a rugged and adaptable physique and some animals and plants which the world seems bent on destroying). Yet Science is a begger at the feast, among all her gifts. A friend says: "Science does not fare as well as the poorest charity." ... What is wrong, really? Is it the scientist or the people of wealth of the Northwest? Has our group been ineffectual in presenting the cause of research? Do they feel that Science is something "in a book"? Working Science is scientists at work. ... Certainly no one living today is not aware that scientific research is in reality "the last frontier." Research, in its present day meaning, signifies going beyond the boundaries of the known. It is beyond this last frontier whence must come the wealth that **is to be** in this great Northwest. The taking of the forests did not bring wealth, i. e. human well-being. Farming is bringing only temporary sustenance. Mining is leaving a useful residue in personal accumulations but destroys itself. Disappearing commercial fisheries did not know how to preserve themselves nor to leave permanent benefits. Research must seek the secret of sustained yield. Usually it must discard the obvious. ... We are now where California was fifty years ago. The Northwest still has resources beyond anything California ever had, but research must touch them. Evidences of the presence and activities of research in that favored state are vast universities, with research departments their most important features, astronomical observatories, a variety of research stations, museums, libraries, aquariums, medical schools with active research adjuncts. All supported by public and private wealth. Forty-seven years ago Lick Observatory began scanning the heavens, and one million dollars went to the California Academy of Sciences, both from the wealth of James Lick. Forty-four years ago Stanford University opened its doors, leading the way in Science. Soon Mrs. Hearst began generous support of the University of California. At a dinner to the new Stanford faculty by the University of California, holiday time, 1891, the newcomers were commiserated because the high schools of California could never supply students to keep so many university teachers occupied! That was only yesterday. ... Now more than three hundred and fifty million dollars worth of private wealth and vast public resources support cultural institutions which have sprung up in a land which Dana, in "Two Years Before the Mast" described so vividly, just a century ago, as abounding in fog, sand and fleas, and producing little of worth except dried hides of cattle. ... Take Dana's formula, some gold to help and hinder, add research. Result: California of today. ... What may the future hold for the Northwest?

NORTHWEST SCIENCE

VOL. IX. SEPTEMBER, 1935 NO. 3

The Association is not responsible, as a body, for the facts and opinions advanced in the papers published by it.

A Message to All Members of the Northwest Scientific Association

By PRESIDENT WILLIAM A. ROCKIE
Regional Director, Soils Conservation Service, U. S. D. A.

Our organization is interested in science; you and I, individually, are particularly concerned with different branches of work within the scientific field, yet I may not feel at all interested in your work. Similarily, you may feel that my phase of work is no concern of yours. This is probably more true of the fundamental sciences than of the applied group. Most of us, unfortunately, have too little information about, and desire for, the fundamental sciences. We, as applied scientists, are more or less inclined to feel that we have graduated from the field of fundamentals. Such a feeling or opinion is fraught with danger. Each one of us has become either so imbued with his own field or so divorced from the fields of others, or both, that he may fail to recognize that any other field than his own exists.

In spite of this tendency for each one of us "to draw into a hole, and then pull the hole in after him," there are certain branches of work that have a very general, if not universal, appeal to everyone. We have concrete evidence of this general interest in certain phases of engineering, forestry, geology, geography, botany and other sciences. Geography, particularly as exemplified in travel, is of intense interest to all of us, either young or old. We all have a more or less "itchy foot" when it comes to "going places" or "seeing things."

Many of our scientific subjects, however, are less glamorous than these more popular fields. My own particular field of work, that of soil studies, has for decades past been one of the most drab and least interesting of our sciences, from a popular standpoint. It has been studied in considerable detail for many years past, but until recently did not excite very general interest even among scientists, and the public none at all.

Events of the past few years have, however, very materially increased the general interest in the formerly very prosaic subject. We have just begun to realize that our very national prosperity is threatened by the loss of our topsoil. Yes, our national existence depends upon what we do with, to and about that resource. A few farsighted individuals have been preaching vainly for soil conservation during the past twenty-five years, but only when measurements were obtained which portrayed the terrific rate of speed with which we were destroying this great national asset, did we sit up and take notice.

We have learned with horror that run-off and erosion are closely related to several of our major national problems. Man-induced run-off and erosion are a highly important and major cause of both floods and droughts, of failed springs and of dried-

up streams, of silted reservoirs and of impoverished communities; in fact, it is very definitely one of our important problems of today and tomorrow.

A realization that we are destroying our land and its productivity faster than any nation has ever before accomplished a similar result, has rather rudely awakened us.

It does not matter in what particular field of work you personally are engaged, man-made erosion is vitally important to you personally. It does not matter if you live in the city or in the country, if you work in an office or out-of-doors, if you are "rich man, poor man, beggerman, thief," it still affects you individually and directly. In fact, it is so close to a number of professions that soil specialists, agronomists, foresters, engineers, economists, range specialists and still others each consider that its study and control is largely within their particular field. Individual differences have arisen between different personalities where the parties concerned forgot that they were trying to accomplish better erosion control and instead got sidetacked on petty arguments about how much better his own field could obtain results than could the other. Probably, all of them were partly right and partly wrong.

The more study we give to the erosion problem, the more we learn that its complexity involves specific research along a hundred different lines; that its causes must be studied through many-colored glasses; and that its control involves problems peculiar to practically every field of research in natural science.

Because of the wide interest in this problem, because of your president's particular relation to that problem and because the membership of this Association and the public generally are not adequately informed on this subject, it has been decided to center our symposium during the coming sessions around the subject of "Soil and Water Conservation." We hope you will consider the discussions that will occur, the arguments that will arise between friends, the differences of opinion on this or on that phase of the subject, as evidence of progress and of added knowledge. It is my hope that some of the nation's authorities on these subjects will be present at our meetings. This will be the **first regional meeting** in the Pacific Northwest to discuss these particular topics.

It is particularly my desire that from such a symposium may come, possibly from the "greenest" listener present, some pertinent criticisms and suggestions on more effectively accomplishing the goal we have before us; namely, control of excessive run-off and erosion, a reduction in our floods, and a rebuilding of our depleted underground water table.

Let's all pitch into the subject, attack it from every angle and bring about a clearer understanding of the true role of the many different factors that are involved, together with a better appreciation of what our soil and our water really means to us.

We, in the Pacific Northwest, have a larger percentage of crystal clear streams and lakes within this geographic region than any other particular section of the United States, but we are rapidly doing all we can to bring these streams and lakes down to the lake-stream standard in other parts of the country. We should learn the facts and then give the matter our most earnest consideration and thought. Erosion control work is new and it is important that our wrong procedures be eliminated as soon as possible. We are pioneering in a practically untried field and we expect to make mistakes. We trust, however, that the wrong methods will slowly, but surely, be eliminated and give way to a rational, proven series of methods for controlling erosion and run-off—a really safe and sane land use.

August 12, 1935.

Anophelines and Malaria in the Pacific Northwest

H. H. STAGE and C. M. GJULLIN
U. S. D. A. Bureau of Entomology and Plant Quarantine
Portland, Oregon

There are authentic records of the occurrence of two species of Anophelines, *Anopheles maculipennis* Meig, and *A. punctipennis* Say. within the states of Washington and Oregon. The authors have failed to find any species other than these in rather extensive mosquito collecting in this region over a period of five years. Although both species are easily taken in late summer over most of the area discussed. *A. punctipennis* appears to be the more numerous.

Our observations tend to demonstrate that neither species shows a decided preference for any certain type of water in which to breed. We have frequently failed to find larvae in water over large areas which seemed particularly promising, but where we have collected them we have found a great variety of water conditions represented. Anophelines have been taken in Washington and Oregon from spring and seepage water in open sun and in partly shaded situations; from semipermanent roadside ditches containing rain water, irrigation water, or river water; along margins of brooks; and from large permanent ponds and small lakes where they may secure shelter along grassy shore lines. As many as 13 larvae, of all instars and both species, have been taken by a single dip along the margin of a swiftly moving irrigation ditch where they were associated with occasional larvae of *Culex tarsalis* Coq. in a protected eddy containing grass and algae. In one locality they were found in fair numbers fromearly June until October in the numerous ox-bow ponds paralleling the Willamette River. In our collections, *Culex tarsalis* has usually been associated with these anophelines and frequently *Theobaldia inornata* Williston and *T. incidens* Thomson were thus associated.

The most common plants in the anopheline-breeding sites in this region are duckweed, *Spirodela;* cat-tail, *Typha;* parrot-head, *Sagittaria latifolia;* an *Eleocharis;* feather, *Myriophyllum;* common arrow- and several species of *Carex, Scirpus* and *Juncus.*

Anopheles larvae have not been taken by us from deep woodland pools which are continuously shaded and consequently lacking in green vegetation, or from excessively foul, stagnant pools. Neither have we been able to collect them from the rather large area along the Oregon coast from Astoria south to Marshfield, although there are numerous holes of seepage water and ponds that appear to be suitable breeding places. We cannot account for this apparent absence, unless it be that insufficient collecting has been done in that locality.

Investigations were also made on the pH values of water containing anopheline larvae over a wide range of conditions and country. While these values ranged from 6.1 to 8.1 the great majority of waters from which larvae were taken ranged from 6.5 to 7.7.

The habits of the anopheline adults in this section are the same as have been observed elsewhere. In the Willamette Valley, Oregon, they are easily found on the ceilings and in protected, darkened corners of outbuildings. In the field they are found in late summer under leaning and fallen tree trunks in close proximity to the ground, where they have sought shelter from the sun and wind. In the South Warner Valley, a prolific mosquito-breeding area of Lake County, Oregon, *A. maculipennis* was very abundant and appeared in numbers comparable to *Theobaldia inornata* and *Culex tarsalis.* However, they were rarely found on one's per-

son in full sun where *Aedes flavescens* Muller and *A. dorsalis* were most annoying.

We have not definitely established how many broods of Anopheles develop in this region. The number no doubt varies since the temperature east of the Cascade Range is lower and the season shorter than west of those mountains. Our observations would lead us to suspect that but two or three broods normally occur on the eastern side of the mountains; and four, or even five, in the Willamette Valley on the western side. On the eastern side of the mountains development ceases early in September, while on the western side it continues until late in October. However, the range of climatic conditions under which anophelines are to be found in the Pacific Northwest vary greatly since they have been found from the seacoast to high inland mountains and from fertile well-tilled valleys to the arid desert.

History of Malaria in the Pacific Northwest.

In a search of the literature relating to malaria in this section, we have found but brief notes here and there. Von Ezdorf,[1] in his "Malaria in the United States," 1915, has made the following statements: "Oregon. Malaria is reported to have been more or less prevalent many years ago, but no cases are now known to originate in the state. Anopheles mosquitoes are also reported as not present in the state." "Washington. Malaria is a notifiable disease, but is reported to be comparatively rare." Barber,[2] in his "History of Malaria in the United States," 1929, does not mention malaria in Oregon or Washington.

It was therefore with considerable interest that the authors in their mosquito studies of this region discovered numerous accounts of malaria by old residents or visitors. It appears to have been introduced over one hundred years ago, to have been an important factor in the decimation of the Indian tribes at that time, and since to have remained, with varying degrees of intensity, endemic to at least the Willamette Valley, in Oregon.

We cannot be sure when the disease first made its appearance along the Columbia River, since our sources of information do not agree in this matter. It is likely that its presence first became known in 1829 or 1830. Bancroft,[3] referring to a settlement of half-breeds, French Canadian servants of the Hudson Bay Company, and trappers from the United States and California says, "from 1829, this cluster of farms stood as a pot-flower of civilization in a wilderness of savagism, the sole effort of independent husbandry in Oregon.

"And strange to say, with these incipient ideas of fixed occupation, and their attendant forest-clearings, house-buildings, and soil stirrings came civilization's kindly savage-destroyer, disease, . . .

"That the ague and fever which in this year of 1829 . . . became epidemic, and raged with such virulence as with the thousands of red men to carry off scores of white and wholly to depopulate certain sections, is to be attributed to the scratching . . . of a few acres . . . seems to me absurd . . .

"But whatever the cause, certain it is that when the soil round Fort Vancouver was first upturned to any considerable extent for cultivation, the fever and ague broke out among the natives in the form of fearful epidemic. White men as well as Indians were seized by it . . . and, during the years 1830, 1831 and 1832 the epidemic was even worse than in 1829."

John Dunn[4] agrees, "After having enjoyed a considerable respite from this visitation (smallpox), and recruited their force and numbers to some extent, they were again, in 1829, and some subsequent years, attacked by another malady, equally fatal—fever, attended with ague." Douglas,[5] however, on his second visit to the Columbia, wrote, "October 11, 1830 . . . . A dreadfully fatal intermittent

fever broke out in the lower parts of this river about eleven weeks ago, which has depopulated the country. Villages, which had afforded from one to two hundred effective warriors, are totally gone; not a soul remains! I am one of the few persons among the Hudson Bay Company's people who have stood it, and sometimes I think, even I have got a 'shake,' and can hardly consider myself out of danger, as the weather is yet very hot.'' DeSmet,[6] confirms the date mentioned by Douglas: ''une fièvre tremblante et contagiuse, qui se declara cette même année 1830. . . .''

The epidemic was widespread and serious for several years. Dr. W. F. Tolmie,[7] a Scotchman assigned to Fort Vancouver during the period, wrote: ''All through the year 1833 intermittent fever was very prevalent. A hospital was erected for Gairdner, in which there were usually from two to three hundred cases. All through the Shoshone country and thence throughout the region of the hypothetical river, Buenaventura, round Klamath and Pyramid Lakes and along the Willamette and Columbia Rivers the disease raged.''

While there may be uncertainty as to the disease to which early historians refer, it nevertheless seems likely that it must have been malaria since the various accounts continually refer to ''intermittent fever,'' ''fever and ague,'' ''ague,'' and even ''malaria.'' The treatment and general symptoms are also indicative of chills and fever.

Information regarding the symptoms is meager, although fever and shaking or trembling is frequently recorded. Townsend,[8] has written: ''The symptoms are a general coldness, soreness and stiffness of the limbs of the body, with violent tertian ague.''

The disease was most apparent during the late summer, the peak of which corresponds well with the reported cases of malaria in Oregon for the past 14 years. John McLeod,[9] Chief Trader to the Hudson Bay Company at Fort Vancouver from 1812 to 1844, wrote on Feb. 25, 1831: ''The intermitting fever which broke out here in August and was still (when I reached here on the first of November and for some time after) raging with great violence.'' Lee and Frost,[10] note: ''In the month of August, in the time of harvest, the intermittent fever began to shake its burning, freezing subjects.'' Townsend,[11] speaking of the absence of Dr. Gairdner, the surgeon at Fort Vancouver, wrote in his Journal: ''October 1st, (1833) . . . In his absence, the charge of the hospital will devolve upon me, and my time will thus be employed through the coming winter. There are at present but few cases of sickness, mostly ague and fever, so prevalent at this season.''

The treatment and history also indicates that it responded to the use of quinine. Townsend,[11] tells something of the attempted cures and described curing a little Indian girl of the fever with quinine after she had been tortured by the Indian Medicine man. Allen,[12] tells of his use of quinine in the treatment of fever and ague: ''In the fall of the year 1832, the fever and ague was very prevalent at Vancouver, and at one time we had over 40 men laid up with it, . . . and I well remember my tramps through the men's houses with my pockets lined with vials of quinine. . . .''

Something has been set down too of the frequent relapses occurring in the same individual, a condition frequently observed at the present time when sufficient quinine has not been taken to effect a permanent cure. This is best illustrated in the case of Jason Lee and is taken from a photostat copy of the daily accounts of the Willamette Station Mission.[13]

''Friday, 20th May, 1836, J. Lee was suddenly seized with ague and on the following day had a very severe fit.''

''Wednesday, 12th July, 1836. J. Lee yet quite unwell, not having recovered from the debilitating effects of ague.''

''Sabbath, 14th August, 1836, Jason Lee

was this morning seized with a severe fit of intermittent fever. . . .''

''Saturday, 22nd October, 1836. J. Lee had another attack of intermittent and so severe as to deprive him of reason for a short time.''

''Monday, 21st November, 1836. Jason Lee set out for Vancouver for the benefit of medical advice having been much reduced by repeated and severe attacks of fever and ague.''

It is impossible to trace the introduction of the disease into the Pacific Northwest, but it was most likely ''dragged across the plains'' as one author aptly describes it. It is a well-known fact that parties from the East and South congregated at Independence, Mo., for their long journey into the Oregon Territory. Is it unlikely that some coming from the lower Mississippi Valley brought with them the gametocytes to be scattered freely among the natives and their fellow travelers by the numerous anophelines in the country? It is possible, too, that it may have been brought in from the sea by sailors and travelers who had come from malarious belts in the United States, or had touched at Central American ports before reaching the Northwest. Be that as it may, the Wilkes' Exploring Expedition during the years 1838 to 1842 apparently did not meet with the disease until they reached Oregon. Speaking of Dr. Babcock at the Methodist Mission near Salem, Wilkes,[14] writes: ''He stated to me that the country was healthy, although during the months of August and September they were subject to fever and ague in the low grounds, but in high and dry situations he believed they would be free from it. . . .'' Somewhat later, in describing the tour of Lieutenant Emmons and his party on their journey from the Columbia to the Sacramento during September and October, 1841, is added: ''Some sickness has made its appearance among the members of the party. Messrs. Emmons, Peale, Rich and Agate all had attacks of ague and fever, and the two last named gentlemen suffered much from this disease. Dr. Whittle ascribed these attacks to the length of time, nearly five weeks, during which they were encamped on the Willamette, and particularly to the position of the camp, immediately on the bank of the river, where it was subject to the damp and fogs.''

This corroborates the statement of Herms[15]: ''That malaria may have been introduced into this state (California) prior to the great gold rush in 1849 is possible, since Cleland states that Lieutenant Emmons and his party entering California in 1841 from Oregon, prior to his entrance into the Sacramento Valley were harassed by sickness, chiefly malaria.''

An indication of the amount of malaria immediately after this period is recorded in ''Medical Statistics of the United States Army,[16]'' and was forwarded to us through the kindness of the Surgeon General of the War Department. For purposes of brevity, we have tabulated data of five representative years together with a total for the 36 years, 1849-1897:

Year	Strength	Malaria	All diseases	Per cent strength having malaria	Per cent malaria of all diseases
1849	366	89	721	23.1	10.9
1855	606	529	1,518	87.2	34.8
1859	2,294	168	3,251	7.3	5.1
1882	994	221	1,458	22.2	15.1
1897	955	10	552	.010	.018
1849-'97	33,288	4,223	40,821	12.7	10.3

Many living residents of Oregon recall considerable ague, particularly in the Willamette Valley, after 1850, although it occurred in minor and major epidemics.

In speaking with the writers about the disease, Dr. M. M. Davis of Eugene, Oregon, stated: ''There was a great deal of malaria in the '50s and '60s and even up in the '70s. Again in the late '90s a

cases in the intervening years, but they were not so numerous. I remember as a boy that nearly every family would have some malaria after school was over in June, and most of the sickness that occurred in the summer was malaria. Mother was a nurse, and, because doctors were scarce in those days, she administered much quinine and chill tonics.''

Col. R. C. Ebert, Medical Corps, U. S. Army, retired, formerly Chief Surgeon of the Department of the Columbia, made this statement in conversation with the authors: ''Portland and the Willamette Valley had plenty of malaria in the '60s and '70s, and congestive chills were common. Some people even died with it at Vancouver, Wash. Quinine was administered by the spoonful, and Jones and Ayers tonics were commonly used.''

Present Status of Malaria in Pacific Northwest.

Malaria was first required to be reported to the State Health Officer of Oregon in 1918. Since that year it has been reported as follows:*

Cases	Cases	Cases
1920— 9	1925— 1	1930—34
1921— 4	1926—25	1931—20
1922— 2	1927—16	1932—53
1923— 1	1928— 9	1933—26
1924— 4	1929—16	1934—23

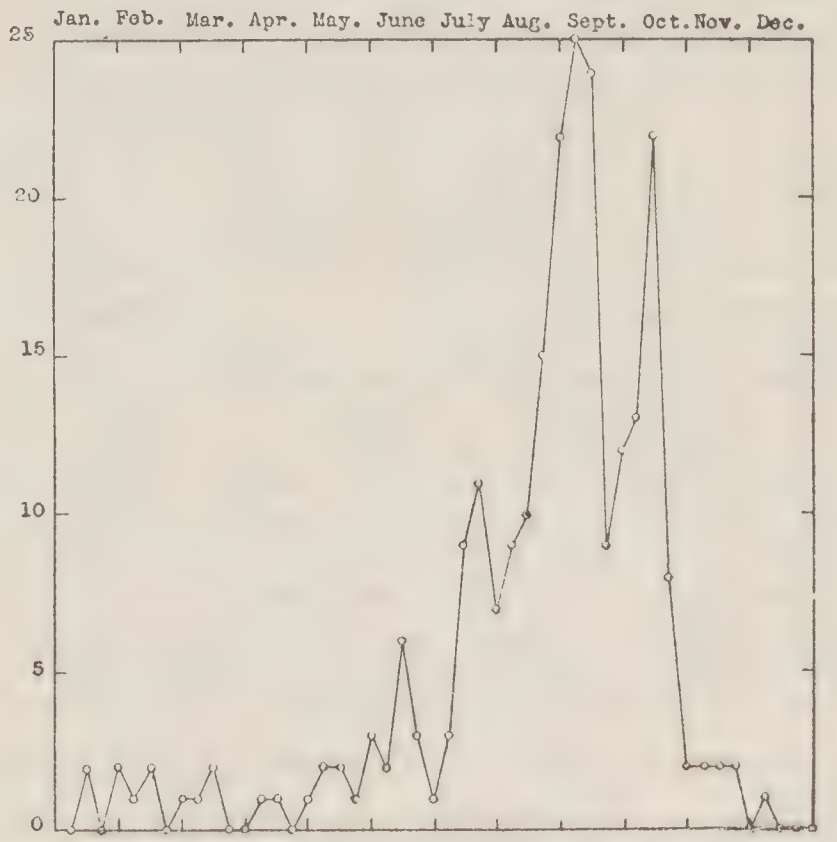
The peak of the season has been determined as the end of the first week in September with the aid of a graph (fig. 1) which was based upon the 243 cases reported above.** The records of reported cases in Washington State show but two in 1928, three in 1929, and three in 1930.***

*Furnished by State Health Officer of Oregon.

**Notifiable diseases are reported to the State Health Officer at the end of each week.

***Furnished by State Health Officer of Washington.

At the request of the State Health Officer, a malaria survey of Lane County, Oregon, was first made by the authors in the early fall of 1931. It was found that there was a decided epidemic of the disease centering particularly about the Noraton School District, part of which lies in northern Lane County and part in the southeastern tip of Benton County. A house-to-house canvass of the district disclosed 24 families, totaling 102 individuals, having authentic records of 41 cases of malaria. Only six families had not suffered an experience with the disease. From the data obtained from the heads of the families in the district, it was found that the typical case cost $14, viz, two visits by a doctor at $5 each, and four bottles of quinine at $1 each. There are a considerable number of permanent ponds in the neighborhood, probably totaling about 100 acres of water surface, and anopheline larvae were easily taken at all of them.



Graph of 243 malarial cases reported weekly to State Health Officer, Oregon, 1920-1934.

A search of the outbuildings also produced a plentiful supply of adults of both species.

In 1932 there were not so many cases

in the Noraton School District, nor is it probable that there were so many in the counties at large although 53 were reported to the State Health Officer. During the house-to-house canvass in 1932, we questioned 28 families totaling 121 individuals, of which families 26 had had cases of the disease. Of the 28 dwellings inspected, only one was fairly well screened with 16-mesh screen, and 17 had no screens at all. Accurate figures for the total number of days all individuals living in the district were sick with malaria, and the number of days sick with all other diseases, could not be obtained for the year 1931, but the proportion must have been very unequal. However, in 1932, by more frequent visits, we were able to secure a better check on these figures and have tabulated them as follows:

Noraton School District, Oregon, Assessed Valuation of District, $42,000 (1932)

Number of families	Number of individuals	Cases of malaria	Total days sick with malaria	Total days sick with all other diseases
28	121	26	161	31

On December 7 and 8 a blood index was also made of this district. Smears were made from 78 individuals, and four, or 5.1 per cent, were found positive for tertian malaria, *Plasmodium vivax*.* These smears were taken from all available individuals and were not limited to persons who had previously had symptoms of the disease. Only tertian malaria has ever been reported by attending physicians.

It seems possible that this more recent aggravated epidemic of malaria had been started by a migration of over 100 Oklahomans into the country. If carriers of the gametocytes came into the neighborhood there was certainly a goodly supply of the anophelines to spread it over the countryside. The climate, too, seems favorable to a reasonable degree for the development of the mosquitoes, for we find that all field crop plants, except a few of those typical of the Cotton Belt, such as tobacco and cotton (and even these can be grown), are found in the Willamette Valley, although the summers are not so warm and moist as in the Southeastern part of the United States, being rather cool and dry. The permanent ponds of clean water evidently supported a thriving population of anophelines, nevertheless.

Because the malarial incidence has been more or less apparent for some time, a correlation of the temperatures in this section with those near the northern limits of an area of severe endemicity was suggested. Since the senior author was well acquainted with the country and the large amount of malaria in southeastern Missouri, the mean minimum and mean maximum temperatures of Cardwell, Mo., were chosen for this study, and compared with the temperatures recorded for Eugene, Oregon, which are very close to those reported for the several observation points in the Willamette Valley. It is especially interesting to note that the mean minimum temperatures are higher in Eugene than they are in Cardwell for the period from November to the latter part of March, inclusive. Likewise, the mean minimum temperature for the six coldest months, October to March, is more than two degrees higher for Eugene than for Cardwell. A limiting factor in the production of large numbers of *Anopheles* and the number of broods may be suggested by the mean minimum temperature for Eugene during the six warmest months, April to September. This is over 13 degrees lower than that for Cardwell.

*Examinations and diagnosis of blood smears were kindly made by Dr. W. V. King of the Bureau of Entomology and Plant Quarantine.

Summary.

But two species of *Anopheles, A. maculipennis* Meig. and *A. punctipennis* Say, have been found in the States of Washington and Oregon. These are relatively numerous throughout both states.

Malaria was first reported in the Oregon Territory in 1829 and 1830 and was the contributing cause of much sickness and death among the Indians and early settlers along the Columbia River at that time.

Malaria has remained endemic to a greater or lesser extent in the Willamette Valley for more than 100 years.

A study of the 243 cases of malaria reported from 1920 to 1934 indicates four peaks: June 14, July 21, September 7 (the greatest), and October 14.

An immigration of over 100 individuals from Oklahoma within the past several years has evidently been the contributing cause for a recent severe epidemic of malaria in the Noraton School District, Lane County, Oregon.

The climate of the Willamette Valley may be favorably compared with that of the northern range limits of the disease in the Mississippi Valley. Moreover, the mean minimum temperature for the six coldest months is slightly higher for Eugene, Oregon, than for that of Cardwell, Mo.

Sufficient information relative to the number of broods of Anophelines and their dates of emergence is not at hand for an attempted correlation with the four peaks of malaria which seem to occur each season.

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Professor Richard F. Flint of Yale University is continuing the study of the glacial features of Eastern Washington this summer, his third field season in this region. This year he is assisted by Morris B. Canning and Charles R. Warren, both of Yale University. This season's work will complete the mapping of the Spokane and Wisconsin drift borders between the Okanogan region and the Idaho state line.

Two papers of the February issue of NORTHWEST SCIENCE received attention in nationally distributed magazines. Dr. Griffin's paper on the Salmon of the Columbia River was rewritten for the first issue of the new magazine, CONSERVATION, issued by the American Forestry Association. Dr. Rich condensed his paper for THE WALTONIAN, published by the Isaac Walton League of America.

Observations on the Life Cycle of Ichthyophthirus, a Ciliate Parasitic on Fish

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State College of Washington

In the seventy years since this parasite was discovered only a few accounts primarily concerned with the life cycle have appeared and none of these agree on all essential points. During a cytological study of this interesting ciliate a considerable mass of experimental and cytological data on the life cycle has been accumulated which bears directly on the problems of the cycle itself.

The life cycle is in two distinct parts. The young ciliate enters the skin of freshwater fish, develops a functional mouth, and feeds and grows in from four to eight days. The full grown matured ciliate with a diameter of 100-1000μ then drops off and encysts. It undergoes a series of divisions until each daughter is less than 40μ in diameter and 100-1000 of the individuals are in each cyst. Nuclear reorganization then takes place, probably by a process of autogamy, and the young reorganized ciliate, usually called a ciliospore, escapes from the cyst and enters the fish.

It is not necessary to wait for a natural epidemic to study this life cycle as claimed by Pearson (1933), since, as many authors have pointed out, fish with a light infection will develop a lethal infection one or two weeks after being placed in an ordinary aquarium without running water.

These parasites have strong, closely set cilia far more powerful and active than those of the average ciliate. It is able to bore into the epithelium of fish (Neresheimer 1908) and force its way through the host's tissues and ingest the cells loosened by its activities. The mouth is a rigid and powerful cup-like organ, 40μ in diameter in large specimens, near the anterior end and is equipped with long cilia which beat continually inward. The continual beat of the body cilia against the epithelium dislodges these cells. Contrary to the usual statements, these cells are only rarely ingested whole but are usually broken into small globules 5μ in diameter which are then ingested. It is the exception to find whole cells within the food vacuoles. The destruction of epithelium is considerable and is fatal in heavy infections, even though the gill epithelium itself is unharmed. The invasion of Saprolegnia often hastens death but a secondary infection is not necessary for death and in fact was found only once under laboratory conditions.

The indigestible material is of course relatively small, the pigment residue of the host's cells being the only obviously indigestible matter. No defecation has been reported in literature nor was it observed in this study. Vacuoles of undigested pigment are present in almost all ciliospores indicating that it may be retained indefinitely within the ciliate. However, much of the pigment becomes concentrated in the cytoplasm of one of the daughter cells during the various divisions and it finally becomes so packed with unwieldy masses of waste that it cannot continue the life cycle. When the viable ciliospores leave the cyst, a degenerate granular mass of waste pigment is left behind. The reorganization within the cyst thus includes the elimination of some of the waste materials.

The presence of a micronucleus during all stages of the life cycle, one of the main distinguishing features of ciliates, has been denied by many authors, the latest of them being Pearson (1933). Haas (1933) demonstrated the micronucleus in all stages and his findings were confirmed in this work. In addition it was found in this study that the micronucleus is readily visible in live ciliates in spite of the granular nature of the cytoplasm. It is a small hemispherical body in the feeding parasite

cleus. Before the first division in the cyst adhering to the surface of the macronu- it migrates to the periphery and divides mitotically slightly before cytoplasmic cleavage. Pearson (1933) and previous authors describe the migration of a body from the macronucleus to form a typical micronucleus. Such descriptions which are common are the result of imperfect cytological evidence and are based on two peculiar processes found in this ciliate. Large basophilic granules of protein are formed within the macronucleus and are extruded during the feeding cycle and early encystment. Also at various times during encystment large ball-like masses of macronuclear chromatin are extruded. Although these latter are absorbed rapidly by the cytoplasm, they are often mistaken for micronuclei since they stain more heavily than the functional micronuclei themselves.

Division takes place normally only within the cyst. Persistent statements in the literature that division occurs in the growing stages in the fish all refer to evidence presented by Neresheimer (1908). On examination of the original paper it was found that he has several drawings of animals showing slight cytoplasmic and macronuclear constrictions, all of which are labeled: "Drawings from memory after lost preparations." These drawings have been interpreted as definite evidence of division during the feeding stage of the cycle. However, the growing ciliates in the epithelium of fish are not turgid and so show numerous shallow clefts at all times, and Neresheimer's evidence must be reconsidered. Division is accompanied in this form by marked redifferentiation in the macronucleus, micronucleus and neuromotor system (MacLennan 1934). None of these structures, however, shows the slightest signs of division while on the live fish. The parasitic stage is reserved entirely for the accumulation and storage of food reserves, while the encysted stage is reserved entirely for reorganization.

The cyst wall is relatively weak and at the end of the division cycle the young ciliospores break out by tearing the wall. They are mature infective ciliates which swim about freely in search of fish. The period of infective life of these spores is usually stated at about twenty-four hours. We have found that these ciliospores are infective for at least ninety-six hours. The percent of infection drops sharply after forty-eight hours indicating that the food reserves are consumed in that time by most of the ciliates. Since the encysted stage may last as long as five days, infective stages may be present in an aquarium or pond at least eight days after the fish are taken out and at least two weeks without fish is necessary to be entirely sure of starving out the parasite in an aquarium.

Ichthyophthirius has been found in all the species of fish from the Palouse River at all times of the year. It has also been found in catfish from the Snake River, collected by Dr. Svihla. An attempt was made to compare the percent of infection of fish during the various seasons of the year under natural conditions. Fish were brought into the laboratory, scraped thoroughly and the scrapings examined microscopically. Ninety-five per cent of the fish show an infection during August, September, and October, and less than five percent during the winter and spring months of freshets and low temperature. The summer infections are also much heavier on each fish than the winter infections. No fish, however, showed any serious damage from the parasite under natural stream conditions at any season.

The results of laboratory experiments correlate very closely with natural infections. Thirty or forty infected fish per gallon aquarium, supplied with running water, never develop a lethal infection and in many cases the infection is lost. One or two fish per gallon aquarium with-

out running water, aerated by plants, develop a lethal infection in one or two weeks. Both natural and laboratory conditions show that the ciliospores and free ciliates while swift in comparison to their size, are not able to swim against even a slow current of water.

No epidemics in streams have been reported so far as I have been able to discover. All reports of epidemics have been either in ponds with practically no water flow or in crowded hatchery conditions. Under natural conditions in the stream the parasite is in balance with its hosts—the continuation of the species is secured without material damage to the host. Pears for game fish from *Ichthyophthirius* under natural conditions recently expressed by Roughley (1933) in connection with Australian problems are in all probability unfounded. Even in crowded hatcheries it is of negligible importance in most cases according to Guberlet (1926) and Wailes (1934).

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THE WEATHER

In addition to the weather forecasts with which the general public is familiar, fire-weather forecasts for protection of forests and advice to aviation make a large part of the work of the Spokane station of the U. S. Weather Bureau. Reports from more than fifty supplemental stations scattered throughout the Inland Empire are received twice daily at this station in addition to regular reports from the stations at Kalispell, Missoula, Walla Walla, Helena and Billings are used as bases for these forecasts. It is hoped that eventually these, together with data collected by the Forest Service, may form a basis for more localized forecasts in the future.

At the Weather Bureau station at the Spokane Airport, pilot baloon soundings have been made to a height of 70,000 feet. Balloon soundings are made and charted two or three times a day in the lower levels as an aid to aviation. Whenever possible the balloon is followed into the stratosphere in order to determine the currents at these altitudes.

"Air Mass Analysis" research is aided by these balloon soundings. In addition, last year voluntary flights by the National Guard Flying Unit were made daily to a height of 22,000 feet with planes carrying automatic meteorological instruments. The data thus collected in the year was esteemed so highly that a contract has been let for a continuation of these flights by an individual flyer.

The total personnel of the Spokane and the Spokane Airport Weather Bureau Stations is ten men.

E. M. Keyser has general charge of the local stations with Malcolm Rigby directly responsible at the Airport Station.

A New Leaf Spot on Oats[1]

RODERICK SPRAGUE[2]

An apparently undescribed leaf spot of Winter Turf (Gray Winter) oats *(Avena sativa)* was observed during the mild winter of 1933-34 in several fields adjacent to the Columbia River gorge in Klickitat County, Washington. It was also found in small quantities on Winter Turf oats in the humid Alsea Valley in Lincoln County, Oregon, in 1932.

The diseased plants were found in small scattered patches which were very conspicuous on account of the reddish-brown color of the affected leaves. The discolored, reddish-brown lesions bore numerous multiseptate, falcate, hyaline spores, which tapered to a sharp point or cilium at the distal end and bore an oblique rodlike cilium or appendage at the basal end. The fungus was tentatively assigned to Pseudodiscosia Host. and Laub. of the Melanconiales.[3]

All but the innermost leaves of diseased plants were covered with indefinite or sometimes red-bordered lesions varying from fawn color to deep brown. This color, in combination with an excessive amount of red anthocyanin pigmentation in the uninjured portions of diseased leaves, produced the reddish-brown appearance of the affected plants. While the lesions did not show any macroscopically visible fruiting bodies, the fruiting surface had a somewhat leathery appearance. The diseased plants were stunted, compacted, and rigid, and the leaves were slightly rolled.

The diseased condition was first noticed in February and was prominent until early April, after which it was not conspicuous. At harvest, the injured plants were about three-fourths of the normal height and their yield was approximately 40 percent less than that of the normal plants. The diseased plants were somewhat more susceptible to the cercosporella foot rot than were those not affected by leaf spot.

In Klickitat County, Wash., the disease was of minor importance, although it attracted considerable attention among growers, who feared that it might become general instead of being restircted to scattered places. From field observations, the fungus evidently is an active parasite but seems to be quickly checked by low relative humidity.

On potato dextrose agar, colonies of hyaline myselium developed from spore dilutions and produced fans or whorls of spores at intervals along the hyphae or less frequently at the end of branches. All transfers to test tube shoots failed to grow.

The hyaline to yellow-tinged mycelium penetrates through the tissues of the leaf both intercellularly and intracellularly and aggregates near and at the surface of the leaf, especially on the upper side. In some instances, the fungus tends to become slightly erumpent but this is not the rule. The conidiophores are mostly simple and compact but an occasional one branches or extends into a sharp pointed, septate seta. The spores are borne singly or in pairs at the tips or sometimes in the forks of conidiophores. The spores, which are mostly two septate, range from nonseptate to three septate. The fungus apparently is an undescribed species of the genus Pseudodiscosia and will be described in a subsequent paper.

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[1] Investigations conducted cooperatively by the Division of Cereal Crops and Diseases, Bureau of Plant Industry, United States Department of Agriculture, and the Oregon and Washington agricultural experiment stations.

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Palouse Topography and Its Relation to Stream History[1]

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Introduction.

In this paper on the topography of the Palouse area, in southeast Washington and western Idaho, the writer is not attempting to define that fascinating division of geologic time known as the Pleistocene, nor will an attempt be made to picture all that transpired in the Palouse during this interval.

Certain assumptions are made, which will probably conform with the generally accepted conclusions regarding Pleistocene geology in this region. The writer is assuming that the Palouse formation was established as a formation in the Pleistocene, that the general plateau area in the Palouse region was uplifted, and that the climate produced streams at least as large as those now flowing.

The Palouse in the Pleistocene.

At the beginning of that period of time in the Pleistocene with which this paper is concerned, the writer pictures the Palouse area as being flat, lying with the ragged fringe of the Moscow Mountains rising 2,000 to 2,500 feet above its eastern margin, as it does today.

An area of some 100 square miles of the basalt plateau around Moscow and reaching westward from the Moscow Mountain front, was entirely covered with the flat or slightly undulating surface of the Palouse formation, except where relatively small buttes of pre-basaltic rocks protruded. The Palouse River and its tributaries descended from the mountains to a poorly drained plain.

Many lakes occupied the depressions in the lowlands, some of which probably attained considerable size and depth. Present evidence which suggests such a setting is the slightly tilted basalt, the overlying Palouse formation which conforms to it, the present dendritic stream pattern and the lacustrine deposits found at various points in the Palouse country.

Uplift.

The duration of the foregoing described early youthful stage is not estimated. However, it is pictured as remaining until regional uplift raised and tilted the basalt plateau slightly away from the mountains. Gradually but with increasing force a youthful stage of erosion was initiated which was to sculpture this region with a rapidity and sameness seldom duplicated.

The Palouse formation probably was not as well consolidated as it is today, heads developed in the watercourses toward the western margin of the area and progressed rapidly to the mountains, to be followed by others until the streams gradients were marked by a long series of falls. Volumes and eroding power fluctuated over a range seldom attained by present streams, as lake after lake was tapped and its waters drained in a relatively short time. Divides were formed, were lowered, and in some cases removed entirely. A great variety of erosional remnants took form as the Palouse region rapidly passed from the youthful erosional stage into its present maturity which today supports no natural lakes or ponds.

When the major drainage heads receded to the granite of the Moscow Mountains and a fairly uniform gradient was established throughout their lengths, the work of the modifying agencies became dominant over headward erosion and its attendant incisions of the stream pattern. Rainfall caused slumping on a vast scale. The sharp cuts and banks of the channels and their erosional remnants, consisting of islands, pinnacles and ridges of the Palouse silt loam, readily "melted" down to form the foundations for the smooth slopes which make the present Palouse topography one of untiring interest.

Rain alone does not receive entire credit for the formation of the present topography. The work of the prevailing southwest wind, particularly in the winter, as it brings great drifts of snow on the lee slopes, does work which ranks snow bank action one of the principal secondary factors in the formation of the topography. A discussion of snow banks is presented by W. A. Rockie[2] in his paper, "Snowdrifts and the Palouse Topography." Snow drifts have maintained slopes on the NE, or lee side, of Palouse hills that are steeper than windward slopes. This has been accomplished by the action of snow in holding drift soil and depositing it below the crest of a hill and also by furnishing water which deeply erodes slopes immediately below drifts.

Stabilization.

As the region passed into the mature erosion stage and accelerated erosion ceased, a firm vegetative cover began to spread over the newly formed hills and valleys until it enveloped the entire region in one of the most luxuriant stands of bunch grass that ever existed. If the writer interprets the record correctly there was very little silt eroded from the Palouse hills during the bunch grass period. These Northwest streams, which such a geologically short time before were knifing their way back toward the mountains, their waters thick with bowlders of clay and silt, were in the bunch grass era running practically clear, their waters inhabited by fish and other forms of life.

Conclusion.

The action of the Palouse streams in establishing gradients rapidly in the Palouse formation is assumed because of the present mode of rapid gully progression in this formation which may be reasonably supposed to be more consolidated and therefore less erosive now than in Pleistocene time.

Present evidence indicates that no special conditions need be assumed to account for the major features of Palouse topography. Events mentioned in this paper are summarized as follows:

1. A flat basalt plateau terminating on the east in the Moscow Mountains.
2. The basalt covered with the Palouse silt loam.
3. Uplift and initiation of a youthful erosional stage in an easily eroded material.
4. Maturity.
5. Stabilization by grass cover.

References

[1] Presented at the annual meeting of the Northwest Scientific Association, Spokane, Washington, December 28-29, 1934.

[2] Rockie, W. A.; Snowdrifts and the Palouse Topography. The Geographical Review. Vol. 24, No. 3. July, 1834.

Need of doing several things which the present quarterly issue of NORTHWEST SCIENCE does not permit, raises the question of increasing the number of issues from four to six or even twelve, which will be proposed to the Council. One contention is that at least abstracts of all papers presented at meetings of N. W. S. A. should be printed as early in the year as possible, unless definite arrangements for full publication had been made by the author. While its columns are chiefly for papers by members of N. W. S. A., it should serve for presentation of scientific papers of vital interest to this region. The paper on "Malaria and Anopheline Mosquitoes in Washington and Oregon," in this issue, is a case in point; a matter very important to the Northwest. Correlation of various lines of research between many and widely scattered institutions, Services, Bureaus, Surveys, etc., can be fostered through acquaintance. The personnel of science here changes rapidly. Such changes should be noted. Forest, Fisheries, Fish and Game, and Soil Conservation have many problems in common. N. W. S. A. and NORTHWEST SCIENCE should furnish a forum for their discussions.

Some Effects of Cultivation Upon Stream History and Upon the Topography of the Palouse Region[1]

EARL VICTOR
Engineer U. S. Soil Conservation Service

Rapid changes are taking place in the stream beds and the topography of the Palouse region. While these changes may not be apparent to a casual observer, they are a matter of grave concern to those who expect to make a permanent home in this fertile region.

Mr. Thomson, in the previous paper,[2] pictured the Palouse area covered with a luxuriant growth of bunch grass. Isaac Stevens, first Governor of Washington Territory, wrote in his diary:

> "Here I was astonished, not simply at the luxuriance of the grass, but the richness of the soil."

Normal erosion was, of course, taking place, but soil loss was balanced by soil formation, and changes in topography were measured over geological periods of time.[3] This paper deals with the immediate past, beginning about 1880. The great influx of settlers in 1877 and 1878 completed the destruction of the native vegetative cover and they placed the entire area under cultivation. Weather records show that precipitation is similar today, and no change has occurred in its distribution through the seasons of the year. Temperature and wind velocity are much the same. The hard winter of '84, or the wet year of '93, is remembered because of its economic effects on a pioneer people poorly prepared for a condition which today would pass without serious inconvenience. Apparently, there has beeen no regional uplift, yet the erosion potentials of our Palouse streams have increased.

The larger streams, whose gradients, in most cases, are determined by basalt and granite outcroppings, are using this new energy in widening their channels and destroying the beautiful valleys through which they flow. Mill Creek, near Walla Walla; the Touchet River, near Waitsburg; and the Palouse River, are examples of this type of channel change.

Many smaller tributaries, even those draining areas of a few acres, exhibit most of the characteristics of youthful streams. There are innumerable cases of head erosion advancing from 20 to 100 feet upstream each year, and developing a grade below the head of approximately ½ of 1 per cent. The height of this head erosion may vary from a few inches to six feet.

The pioneer roads followed water grades, crossing and re-crossing the smaller streams. The writer can recall when many such crossings became too deep and bridges were necessary; then, in a few years, a larger bridge replaced the old. A 40-foot bridge, 14 feet high, now spans the channel near the headwaters of the South Palouse. This place was not bridged until 1887. Dead Man Creek, in Garfield County, was crossed at any point with team and wagon in 1880. Now it is 25 feet deep and 100 feet wide. From one seven-mile section of this gully, over four million cubic yards of material have been carried into the Snake River.

In a great many places, particularly near the eastern mountain boundary of the area, bottom lands and small meadows formerly were considered too wet to farm. When the head erosion of a stream had advanced through these meadows, the lowering of the water table permitted them to be farmed. Thus, an indication of the time when these gullies were formed is established. Most of these meadows investigated by the writer, particularly those near the head of South Palouse River, were first cultivated about 1890, which was, in general, 10 or 12 years after the rest of the farm.

On the steeper south and southwest slopes, clay is showing through the topsoil,

which was formerly approximately 7 inches deep. Mr. W. A. Rockie[4] has estimated the average soil lost in this Palouse area to be about ⅓ inch each fallow year. This is at least 100, and possibly 200, times as fast as nature builds soil. At times of torrential summer rains, or cloudbursts, soil may be lost, over the area affected, at the rate of 700 tons per acre during one storm.[5]

Snowbank erosion on the lee slopes is noticeably changing their gradients. No definite measurements are yet available. However, the estimated loss of soil below snowbanks on these slopes is at least 1 inch, and the deposit of windblown material on the snowdrift is from ¼ to ½ inch for each year that the land is in summer fallow.[6] The writer has experienced these increased gradients during farming operations over a period of years. It is not uncommon now to notice small patches of wheat left standing by the harvester on these steep northern slopes. This wheat is left because the land has become too steep to harvest, notwithstanding the increased price of wheat and improved harvesting machinery.

From the evidence presented, the following conclusions are reached:

1st, there was very little erosion during the bunch grass era. Flood waters ran almost siltless. Shallow streams meandered through pleasant meadows.

2nd, the stream channels and topography are in a process of rapid change. Flood waters are heavily charged with silt. Practically all streams have deep, narrow channels. Accelerated erosion has replaced the normal erosion of centuries.

3rd, the removal of the vegetative cover by intensive cultivation is the only erosional factor to change appreciably in the last 60 years.

References

[1] Presented at the annual meeting of the Northwest Scientific Association, Spokane, Washington, December 28-29, 1934.

[2] Thomson, J. P.; "Palouse Topography in its Relation to Stream History," delivered before the Northwest Scientific Association, 1934.

[3] Lowdermilk, Dr. W. C.; "Acceleration of Erosion above Geological Norms." Paper before the American Geophysical Union, 1934. 15th Annual Report, page 505.

[4] Rockie, W. A., Regional Director, Northwest Soil Conservation Service.

[5] Rockie, W. A.; "Effects of Torrential Summer Rains in Southeastern Washington." Bulletin No. 271 of Washington Agricultural Experiment Station.

[6] Rockie, W. A.; "Snowdrifts and Palouse Topography." Geographical Review, Vol. XXIV, No. 3, July, 1934.

Names of the Section Officers for the coming meeting of Northwest Scientific Association are printed below for the convenience of the members:

BOTANY-ZOOLOGY—Dr. Leslie Hedrick, Whitworth College, Spokane, Chairman; Dr. Leroy Glass, Zoology Department, Idaho University, Moscow, Secretary.

CHEMISTRY-PHYSICS-MATH—J. L. Culbertson, Washington State College, Chairman; L. C. Cady, University of Idaho, Moscow, Secretary.

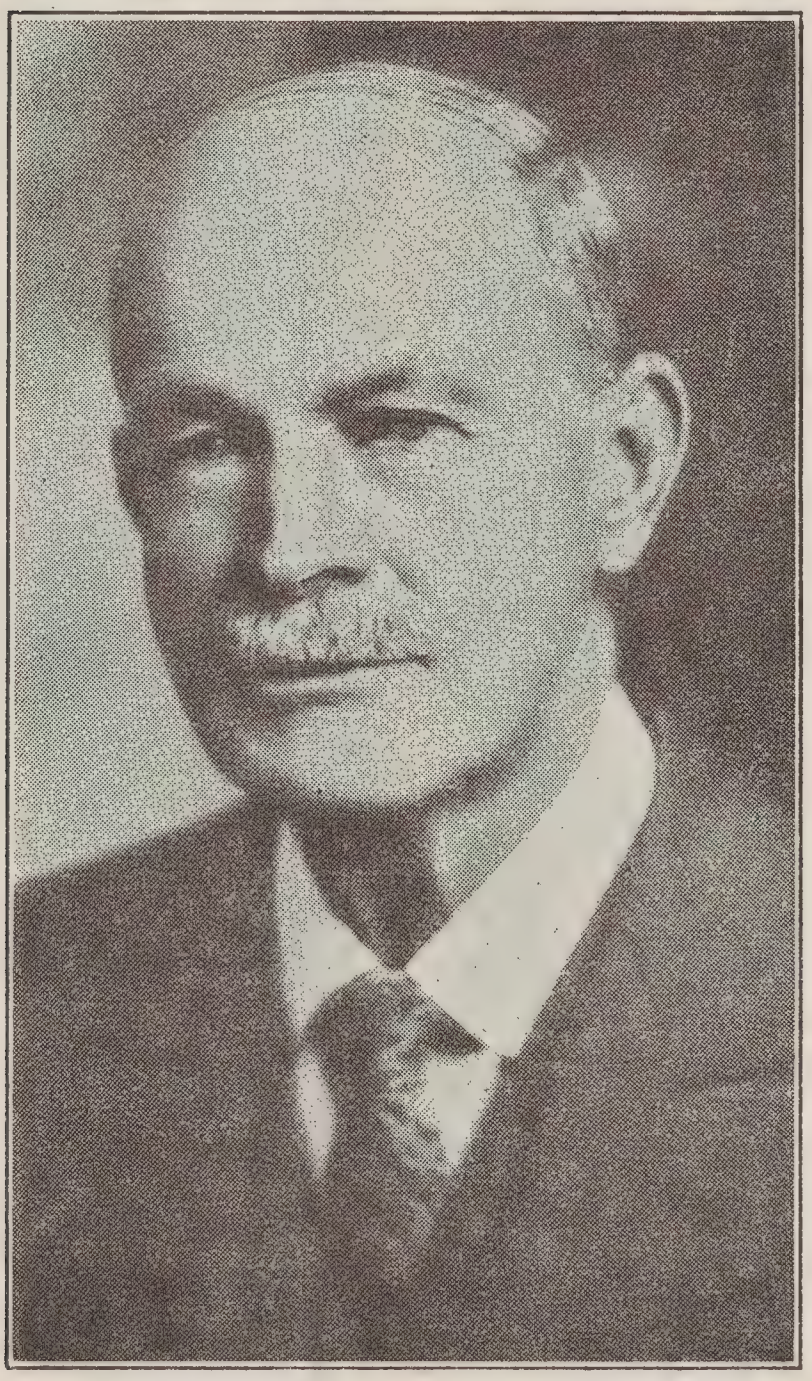
ENGINEERING—M. K. Snyder, Washington State College, Chairman; J. G. Woodburn, Washington State College, Secretary.

FORESTRY—Dean R. E. McArdle, College of Forestry, University of Idaho, Chairman; S. E. Clarke, Extension Forester, University of Idaho, Moscow, Secretary.

MEDICINE—Dr. R. F. E. Stier, Paulsen Building, Spokane, Chairman.

PSYCHOLOGY-EDUCATION—Dean A. A. Cleveland, Washington State College, Chairman; W. C. Ryan, Assistant Superintendent County Schools, Spokane, Secretary.

SOCIAL SCIENCE—George Fuller, Public Library, Spokane, Chairman; H. I. Deutsch, Washington State College, Vice Chairman; L. K. Bowersox, Whitworth College, Spokane, Secretary.



THOMAS A. BONSOR

Thomas Athelstan Bonser, naturalist, born in Dayton, Ohio, September 21, 1860, of German parents, died at Spokane, Washington, of coronary thrombosis, August 4, 1935. His early boyhood was spent in Dayton. He grew to maturity as a farm boy, married Edna Florey in 1886, with whom he had one son, who died in infancy. After her death he married Ethel F. Wilcox in 1906 with whom he has two children, Mildred and Donald, who with the wife survive him.

His scholastic education was obtained in the Dayton city schools, the "little red schoolhouse," Ohio State Academy, Otterbein College, and Chicago University, Otterbein granting him the degree of Ph. B. and Chicago University that of M. S. The financial handicaps under which his education was obtained and his persistence of aim are reflected in the fact that he was 39 and 43 years of age respectively at receiving his degrees. For his master's degree he majored in botany under Dr. J. M. Coulter, with whom he enjoyed a close friendship.

Though preeminently a botanist, he knew his rocks and fauna, interpreting and speaking their language with remarkable fluency. He read widely, his personal diary showing the readings of 473 volumes of more than 148,000 pages in the last 8 years. He was a great lover of the out-of-doors.

In 1895, while working at an Experiment station of the Ohio State Academy of Sci-

ences, on Lake Erie, he discovered the cause of the ''seiches'' or lake tides on the Great Lakes to be barometric and wind variations, conclusions of an extended research by the Carnegie Institution, published in 1922, fully confirming the same findings.

His Master's thesis, ''Ecological Study of Big Spring Prairie, Wyandotte County, Ohio,'' was a 96-page publication showing the definite encroachment of forests upon prairie land.

He began teaching in the country schools of Ohio in 1884, was principal at West Carrolton 3 years, superintendent at Carey, 12 years.

When acting as official photographer for a Chicago University expedition in 1903 to the Northwest, he was inspired by a vision of the Northwest's opportunity to a scientist and a little later accepted a teaching position in the biological department of South Central High School, Spokane. Thus began 30 years of teaching in Spokane, including 5 years at Spokane College and 21 at North Central High School. He retired in 1933, when a notable banquet was tendered him by the North Central faculty. In his teaching he emphasized the importance of studying afield and did much hiking with his pupils, who had great respect for him.

He was a great club leader, heading tree clubs, butterfly clubs, fossil clubs, flower clubs, nature study clubs whose members ranged from young to old. He led many parties over the hills of the Inland Empire. As late at June 30, 1935, as a guest of the Mountaineers, he climbed Chilco Peak in the Coeur d'Alenes, aiding in identification of wild flowers. At time of his death he was Vice President of the Northwest Scientific Association and its only Honorary Life Member.

He was a Boy Scout councilor and examiner in six subjects, and has examined hundreds of boys seeking Merit badges.

As botanist he made a survey of hay fever plants in six Northwestern states and was clinical consultant for Hollister-Stier laboratories, results being published in the March, 1930, Journal of Allergy, St. Louis.

To Mr. Bonsor, perhaps, more than to any other person, Spokane is indebted for its splendid Public Museum. Through its growing and removal stages, through several locations, he has been during the last 20 years its chief counsel, its guiding genius, protecting it, encouraging contributions to it, and helping the public to use it. His own personal botanical collection there is upwards of 5000 specimens, while the Spokane Art Association and the Eastern Washington State Historical Society are either owners or custodians of many thousands more.

One of his students, of 20 years ago, later a fellow teacher, has this to say of Mr. Bonser:

''His students at once felt they were in the presence of a scientist, not just another science teacher. We teachers owe him a great debt. Even in this companionship he was a teacher of teachers. His memory was prodigious and his interests omniverous. These characteristics of him have impressed me:

(1) His tremendous energy and drive; (2) his wonderful memory; (3) his ability to stick to a problem till he had attained mastery; (4) his willingness to share his time with children and adult students; (5) his gentle character and genuine brotherly feeling; (6) his wide diversified field of knowledge; (7) he was a scout, an excellent camper, and a real friend. No one fills his place. It is empty. Only the memory of the beautiful life of a great worker remains to comfort us.''—E. M. K.

FOREST RESEARCH NEWS

L. F. Watts, Director of the Northern Rocky Mountain Forest and Range Experiment Station, states that the Federal Building in Missoula is scheduled to be enlarged by the construction of a $600,000 addition. Both the Experiment Station and the Regional Office wll benefit by the provision of much needed office and labroatory space. Plans, already drawn, include separate laboratories for physics, chemistry, biology, pathology, silviculture, fire, and range management research by the Experiment Station. A laboratory is also provided for research in wild life and game management which is now under the supervision of Howard R. Flint of the Regional Office.

Research in range reseeding and management, supervised by L. C. Hurtt of the Northern Rocky Mountain Forest and Range Experiment Station, is being accelerated and expanded this year under an increase of $20,000 available July 1, 1935. The studies of reseeding so far made indicate that a very great part of the more than 4,000,000 acres of plowed and abandoned dry farm land in Montana can be reseeded at a cost which will be fully justified by increased carrying capacity and by reduced wind and water erosion. Preliminary data for one study of range management has also shown conclusively the quadruple dangers of overgrazing: (1) Less weight per head of stock. (2) More hay used for feed. (3) A poorer calf crop. (4) Reduced volume of future forage. These were all produced by overgrazing.

Forest products research, as now handled by the Northern Rocky Mountain Experiment Station, is designed to be of maximum service to the logging industry, the State, and the Government in (1) woods and mill utilization; (2) logging and milling practices; (3) species utilization; (4) wood preservation; and (5) forest products statistics. I. V. Anderson is in charge of this work. Two outstanding publications of the past year were "Application of Selective Logging to a Ponderosa Pine Operation in Western Montana" and "Why Selective Cutting of Ponderosa Pine Pays."

Silvicultural research at the Northern Rocky Mountain Station is now being supervised by L. G. Hornby. I. T. Haig, formerly of the silviculture staff, has been recently transferred to the Washington office of the Forest Service. R. H. Weidman is now giving his full time to research in planting. Silvicultural releases accepted for publication or in course of preparation include (1) "Factors Controlling Initial Establishment in Western White Pine" by Haig; (2) "Natural Reproduction of Western White Pine" by Weidman and Haig, and (3) "Method of Cutting; Its Effect on Reproduction in the White Pine Type" by Haig and Wellner.

The two branches of fire research, fire control planning formerly supervised by L. G. Hornby, and fire danger measurement handled by H. T. Gisborne, are now under the direction of Mr. Gisborne. Mr. Hornby is now preparing a report describing the systematic methods of fire control planning which he originated and developed. This research is an example of a project so urgently needed that the major results were put into practice even before they could be published. By use of Hornby's methods the lookout and smokechaser coverage of the National Forests in this region has been improved by 20 per cent with no increase in the number of men needed by the forest protective organization.

Research in fire danger measurement has likewise been put into practice before complete results could be published. In this case, however, the research could not be considered complete until the methods evolved had been tested by actual field use. During 1935, fire danger measurements and ratings are being made daily

at 63 field stations on 10 National Forests. From these data, and by use of the fire danger meter designed for this purpose, danger is now rated on a numerical scale so that conditions on different National Forests may be reported and compared accurately. A Department of Agriculture Bulletin entitled "Measuring Fire Weather and Forest Inflammability" by H. T. Gisborne, is now in course of publication.

MR. HOWARD R. FLINT

Ex-President of N. W. S. A.

When a man spends most of his spare time in sunshiny weather up in the air "shooting up" the landscape of several states with a great camera he is apt to arouse feelings of envy in the minds of more lowly mortals. Mapping and fighting forest fires from the air, on earth a recognized leader in forestry and related fields and an administrator helping to make a success of the New Deal's universally recognized most successful departure, the C. C. C., are activities and achievements so varied and interesting that all readers will be glad to have the brief biographical material here presented.

Mr. Flint was born in Minnesota, and has been a student in the Universities of Minnesota and Montana.

To this, one of his associates, Mr. M. H. Wolff, Assistant Regional Forester at Missoula, has added the following:

Born some 50 odd years ago, Howard Flint lived on a farm until the age of 17. Then until about 25 he worked as a carpenter, a millwright foreman, as a timber cruiser and scaler, during the times in which he was getting his preliminary education. He entered the Forest Service as assistant ranger in the Lake States in 1910, left for a period of time to engage in work as a woods foreman, and returned again in 1917. From that period on he has successively progressed through timber cruiser, lumberman, Forest Supervisor, to Regional Inspector in charge of fire work, special land appraisal assignments, and is now engaged primarily in work as liasion officer in the Forest Service and the Army Civilian Conservation Corps, and in the development and pursuit of airpalne mapping. Between times in his present capacity and during all his past years, he has found time to carry on investigations in range management, fire fighting, and to continue his prominent place among his associates as a student, writer and lecturer on National Forest administration, forest fire control, air photography, and many allied biological and botanical subjects.

Since Mr. Wolff wrote the above Mr. Flint has had assigned to him the work of supervision of game and fur-bearing animals and the fishes of the waters of the forests of the Northern Rocky Mountain region.

Dr. Freeman, Secretary-Treasurer of N. W. S. A., will propose change in the constitution of the Association establishing life memberships on payment of $25.00. Dr. Freeman has already received one remittance for such membership.

Dr. Reuel B. Frost of the geology department of Oberlin College has been visiting instructor in geography in the State Normal School at Cheney, Washington, in the summer school just ended.

SCIENCE AND THE ASSOCIATED PRESS

One of the most important services to Science in the Northwest is the sincere effort of Mr. Floyd W. Lansdon, Spokane representative of the Associated Press, to render with appreciation of values and without distortion, news of the work of scientists of the region.

Members of our Association commonly underestimate the news value of papers presented at our meetings. The letter which follows indicates what members can do to aid Mr. Lansdon. Let us all give him all assistance possible by furnishing papers or abstracts early enough to enable him to put them in form for such use.

Editor, Northwest Science,
Dear Sir:

Let me take this opportunity to thank you for your splendid cooperation in obtaining newsworthy material from the Northwest Scientific Association for our service. Frequently we have been able to use many stories based on speeches and papers by members of your organization.

I suspect there has been much material in speeches and papers that has not come to my attention, and thus was not given the distribution its newsworthiness warranted. If you could do anything more to correct this situation I would be most happy.

As a suggestion, would it be possible to have copies of papers or speeches, or abstracts, furnished me, not only for your conventions, but other times? If this information were placed in my hands, I could make much better use of it than I have been able to heretofore.

Thank you again.

Very sincerely yours,
FLOYD W. LANSDON.

No direction as to procedure to secure grants-in-aid for scientific research by our members has been furnished Northwest Science by the Board of Trustees at time of going to press. Corresponding with Mr. Weidman, Chairman of the Trustees, by prospective applicants, will no doubt bring this information in time for securing aid for work in the current year.

Dr. Arthur S. Hazzard, Associate Aquatic Biologist, U. S. Bureau of Fisheries, in charge of field investigations for the Bureau and teaching part time in the University of Utah at Salt Lake City, is resigning early in September to take over the Directorship of the Institute for Fisheries Research at Michigan. Just another example of the draft the East is able to make on the West for good men. No place is such service as Dr. Hazzard is able to render worse needed than in the West.

The symposium idea implanted at the last annual meeting seems to have taken root. A soils symposium of unusual importance is to be a part of the next meeting.

BROOKLYN BOTANIC GARDEN MEMOIRS

Volume I: 33 contributions on genetics, pathology, mycology, physiology. ecology, plant geography, and systematic botany. 1917. 521 pages. Price $3.50 plus postage.

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Volume III. The vegetation of Mt. Desert Island, Maine, and its environment. By Barrington Moore and Norman Taylor. 151 pages, 27 text figures, vegetation map in colors. 1927. Price $1.60.

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QUALIFIED STENOGRAPHER, now post-graduate in the Lewis and Clark High School of Spokane, seeks a part-time position to pay college expenses. References furnished. Lena McCoury, Route 4, Spokane, Wash.

NORTHWEST SCIENCE

NOVEMBER, 1935

Vol. IX No. 4

Published by

The Northwest Scientific Association

Single Copies Thirty-five Cents

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-:- NORTHWEST SCIENCE -:-

A scientific journal devoted to the dissemination of scientific knowledge and encouragement of research in the Pacific Northwest

PUBLISHED QUARTERLY BY

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NORTHWEST SCIENCE

Is Entered as Second Class Matter, April 5, 1927, at the Postoffice at Cheney, Washington. Office of Publication, Cheney, Washington. Subscription Price to Members, Including Dues, One Dollar per Year; to Non-Members, One Dollar.
Volumes I. to VIII., 1927 to 1933, Each $1.25.

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-:- EDITORIAL COMMENT -:-

MILLER, VINCENT, VON ENDE, CLAPP, BONSER, FLINT—Fallen in line of duty in a time too brief. All leaders in Northwest Scientific Association, holding responsible official positions as Councillors or Trustees. How alike they were in the qualities that drew men to them—genial, unassuming, democratic, hard-working, open-minded, broad in interests combined with intense specialization. To each came the reward of great success in that which most interested him. As time comes to consider, we see that each has left his own memorial in some objective won: Miller, an experimental forest; Vincent, traditions of public service; von Ende, a great department in a university; Clapp, geology of the Rocky Mountains, and traditions in a university; Bonser, a museum; Flint, Aviation to the service of Forestry. For us, "Carry on."

A HALF A CENTURY AGO, when the University of Michigan was a leading university west of the Allegheny Mountains, President Angell of that institution established a policy of charging to students who came from without the borders of that state no fees that were not charged to citizens of the state. In defending this policy before the state legislature he presented figures to show that many students who attended the university at Ann Arbor became citizens of the state, and he argued that a college graduate was worth more as a citizen than one not so equipped. Under Dean Cooley's wise direction the College of Engineering of that school became a great institution. Engineering students became citizens of Michigan and found employment in Detroit and other neighboring cities. President Angel and Dean Cooley had never heard of an automobile, but down in the natural gas belt of neighboring states crazy inventors were playing with "gasoline buggies" and "horseless carriages." As the gasoline engine developed from a "one-lunger" to the "four-cylinder" estate these inventors did not seem quite so crazy. They drifted into the state of Michigan where engineering help could be found in solving their problems. That automobiles come from Michigan is not an accident.

Across Lake Michigan to the westward was an extremely poor state of Wisconsin, from which lumber barons were stripping the timber and selling potato farms to settlers. As luck would have it, in Madison there was a university under wise direction. In its faculty was a genius named Babcock. He was professor of Agriculture. Dairying at that time was quite an individualistic occupation Its products were without standards. Professor Babcock produced a "centrifuge milk-tester" which made it possible to calculate the amount of "butter-fat" in the milk. Prosperity came to the farms where cows were kept for milking. At present both Michigan and Wisconsin are in the "billion dollar" class. Both had been stripped of what might have been a great resource and were almost without assets.

What happened to these states has happened repeatedly to every state in the Union where research has been applied. Every state which commercial boosters have called "billion dollar states" are states where big investment in great universities has preceded their growth in wealth. Proof of this is shown by Texas and North Carolina being the only Southern states in this class and California the only Western state.

The four Northwest states of the United States, Montana, Idaho, Washington and Oregon, have natural resources absolutely without parallel on the continent. Their educational institutions fight tooth and nail for every penny of their support. Professors of great ability are lost and (or) refuse to come to these institutions because of the pittances on which they must live. And these states stay in the "poor state" class. Scientific research is the only source from which new wealth has come in a half a century. States must learn this exactly as Industry had to learn it.

MONEY FOR RESEARCH for members of Northwest Scientific Association will be allotted in the month of December. The amount is small which is available at this time, but members who would be able to complete work already under way with the help of fifty to two hundred and fifty dollars should at once make application to Mr. R. H. Weidman, Chairman of the Board of Trustees, N. W. S. A., Forest Experiment Station, Missoula, Montana.

NORTHWEST SCIENCE

VOL. IX. NOVEMBER, 1935 NO. 4

The Association is not responsible, as a body, for the facts and opinions advanced in the papers published by it.

THE 1935 MEETING

Scientists in the Northwest should know more fully and more understandingly, the major objectives of the national program of soil-water conservation that is now being developed. It affects you and it affects me, whether you are butcher, baker, or candlestick maker. It affects your life whether you are a farmer or a preacher, a lawyer or a banker, a schoolteacher or a laboratory man. Without good soil and good water, this would be a tragic land on which to live. Just try living in those locations which have neither good soil nor good water. It is bad enough to live where either one of the two is bad, but to combine bad soil with bad water—and then to be forced to call such a location home—would be a tragedy to almost anyone, anywhere.

We, in the Northwest states generally, are blessed with good water. In fact, there is no finer water anywhere than that in our mountainous headwaters. There are relatively few communities in our Pacific Northwest that do not have good water.

And so it is—generally speaking—with our soil in this region. True, a large percentage of our land is too thinly covered with soil, but usually it is good in quality. Only in limited areas, is our soil such that we could call it bad, and its badness in those particular areas is more due to man's mistakes in using the land and the water than to Mother Nature's handiwork.

I hope that each one of us—all of us—may more fully appreciate and recognize the assets that our fertile soil and our clear, pure water represent to the Pacific Northwest. W. A. ROCKIE, President.

THE ANNUAL MEETING

The Northwest Scientific Association will hold its annual meeting at the Davenport Hotel Friday and Saturday, December 27th and 28th. Highlights of the meeting will be a symposium on the conservation of natural resources with particular reference to the preservation of the soils of the Inland Empire. Authorities from the Department of Agriculture in Washington and from institutions in the western states will speak at the general meetings both Friday and Saturday mornings. Friday noon there will be a meeting and a joint luncheon with the Associated Engineers of Spokane, at which a man of national reputation will speak on geologic and engineering problems of current interest.

Friday night at 6:30 the annual banquet of the Association will be held at the Davenport. Retiring President Thomas Large will give the main address on "The Challenge of Inland Waters."

Section program meetings will be held on Friday afternoon, Saturday morning and Saturday afternoon for separate sections in Botany-Zoology, Chemistry-Physics-Mathematics, Education-Psychology, Engineering, Forestry, Geology-Geography and Social Science. The Medical section will provide a program for an open meeting for which the time will be arranged.

A large number of papers and an unusually interesting program is indicated. Plan to attend the two-day session. Bring a friend to join the Association and have a record attendance at the 1935 meeting. Programs will be mailed to members about December 15.

O. W. FREEMAN, Secretary.

NOV 29 1935

Fossil Bearing Basalts

(More particularly the Yakima Basalts of Central Washington)

GEORGE F. BECK
Science Department, Washington State Normal School, Ellensburg
(Research Fellow, University of Washington)

Such an overwhelming majority of the floral and faunal remains of the earth's crust have been yielded by rocks of sedimentary origin that generalized statements concerning the occurrence of fossils often neglect their more rare appearance in metamorphic and igneous rocks. In fact there is the temptation, after volcanic tuffs have been excluded as more or less sedimentary, to venture the positive assertion that by their very character igneous rocks are incapable of recording the presence of the life which may have existed at the time of their extrusion.

As a result, most that has been written concerning fossil floras and faunas refers to their occurrence in sediments and only occasionally and incidentally, as it were, does the literature take up the matter of fossil remains in igneous rocks. There has come to the writer's attention brief reference to the tree molds (and casts)[1] of Mt. St. Helens,[2] Pacific Coast,[3] Craters of the Moon,[4] and those of recent trees in the lavas of the Hawaiian Islands.[5]

Articles treating of petrified trees in basalts are seldom clear as to whether the tree remains are to be found in the basalts or in sediments between the lava flows.

Careful and exhaustive studies[6] have been reported and are in progress concerning the fossil floras of the "marginal" and "interior" sediments intercalated or otherwise associated with the Yakima Basalts of Miocene age. Less has been said about the diatoms, fresh water molluscs, insect, fish, and vertebrate remains which have been recovered from these same deposits.

Very little if anything has been written concerning the existence of fossil plant and animal remains within the Yakima Basalts themselves, though locally abundant, especially with respect to trees.

I. C. Russell[7] observing the presence of petrified trees in the vicinity of the Slide Ranch (his Simcoe Slide) (and in the Wenas Basalts probably as he himself suggests) accounts for the presence of these trees as burial upright in a volcanic ash phase of the lavas. There is hardly any doubt that these petrified remains occur in palagonite breccias which are commonly associated with ellipsoidal lavas and that their burial is after the manner characteristic of the petrified forests encountered in the main Yakima series.

Only after painstaking work in the field has evidence accumulated pointing to the method of preservation of the petrified forests, standing stumps and prostrate logs have apparently been surrounded by liquid lava. As to the introduction of free logs into the basalt—and they make up whole "forests" at given horizons—four alternate hypotheses have been considered. Each of these hypotheses assumes the presence of standing water in the basin in which the lava came to rest, for ellipsoidal lavas invariably accompany petrified trees or their molds.[8]

The four hypotheses follow: 1. The logs might have been carried by the lava from some adjacent upland. 2. They might have been encountered afloat in the lake. 3. They might have been encountered waterlogged on the bottom and subsequently buoyed up by the denser basalt. 4. They might have been picked up from the lake floor already in a petrified condition. Significant factors in arriving at a choice of hypotheses have been four, namely: 1. The frequently waterlogged and bleached appearance of the logs. 2. The consistent attitude of the logs as to dip and direction as though trapped while in

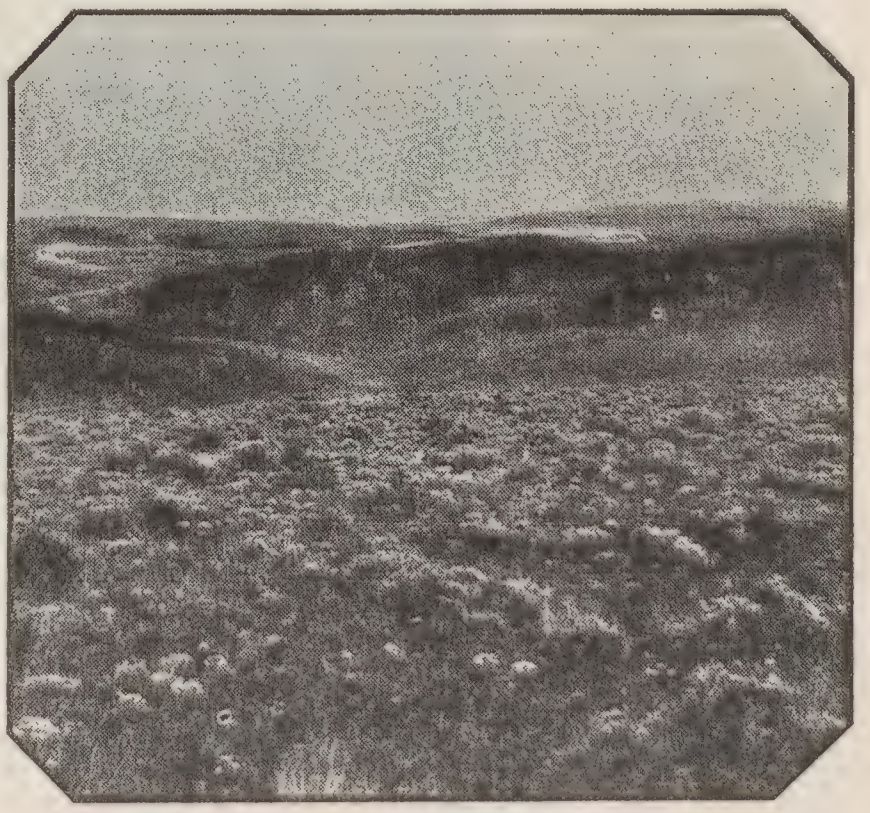
motion away from the onflowing lava. 3. The tendency of molds and petrified forests to occur at separate horizons, petrified trees on the whole being confined to those lavas which show the effect of aqueous chilling through the development of palagonite breccias. 4. The lack of petrified woods or molds in the lake bottom sediments.

A large 5-foot Juglans (black walnut?) (tree No. 12) from the pillow lavas above the Vantage lake bed. This specimen is one of two among several thousand known logs at this horizon which includes the bark. Three miles west of Vantage Bridge, Ginkgo Petrified Forest. Note ellipsoidal pillow immediately above log and to right.

The weight of evidence at this time strongly favors the hypothesis that the logs were adrift in the lakes which served as a catch basin for the respective basaltic flows. Likewise rooted trees seem to have been drowned at the time of the lava outpouring which engulfed them.

Whether or not we have considered and arrived at the proper hypothesis as to the entombment of these Central Washington forests, there can be little doubt but that the process was effected in the presence of standing water. Abundant water at hand seems to have accounted for the preservation and immediate petrifaction of the trees. Less abundant water seems to have resulted in the production of molds only. The water must have served as a protective agent against the heat of the liquid lava, for it does not seem that the exclusion of air can be invoked consistently to account for failure of the trees to oxidize. On the other hand abundant water seems to have been necessary for the chemical reaction which set free the quantities of siliceous gel which invaded the cell lumens of the trees entombed. To repeat, it seems that the water served the dual purpose, when abundant, of protecting the logs from combustion and of providing for their relatively rapid petrification.

Intermediate and advanced stages of dehydration of the siliceous gel is encountered as trees are dug out from the basalt. Crystallization with accompanying sectionizing, and loss of wood structure is apparent in many of the trees that have been exposed to the weather indefinitely. Logs which have been exhumed from a moderate depth are found opaline in character and unbroken into sections while



General view of the Vantage Forest horizon, 500 feet more or less within the Yakima Basalts, looking east toward the Columbia River from a point three and a half miles west of the latter, Ginkgo Petrified Forest.

cell and ring structure are faithfully preserved. For a masterly, though brief, account of wood opalization see Dr. Wie-

land's account in a recent issue of Science."

Standing forests provide an intermediate type between sedimentary and "basaltic" fossils in that roots, root hairs, soil, and embedded leaves are frequently completely silicified as a result of a basaltic inundation.

Having once arrived at the foregoing conclusions concerning the preservation of floras in basalts it eventually came to our attention that animals could just as readily furnish material for petrifactions and molds. Insect eggs and worm or insect borings were known from the petrified woods. Theoretically, we had already visualized petrified animals or molds in the Yakima Basalts when word came of the discovery of a mammal mold at Blue Lake, Grand Coulee. After a few weeks and through the courtesy of the University of Washington, we came into possession of some bone fragments said to have been recovered from the cavity in question. Mr. and Mrs. G. B. Peabody and Mr. and Mrs. H. B. Friele of Seattle had made the discovery, and in August the former couple directed us to the locality. The most casual examination was sufficient to establish the mold character of the opening and to permit bone fragments to be taken from the leg extensions. The mold lies orientated with and associated

One of the finer Piceoxyla (tamarack?) (tree No. 6) which make up 50 per cent of the Vantage Forest in Ginkgo Petrified Forest. It occurs in well-defined pillow, or ellipsoidal, lava.

with a series of tree molds, and as to be expected in a mold "forest" the bones are not petrified. The left mandible with teeth more or less intact, has, with other fragments of this supposed rhinoceros, been forwarded to Dr. Chester Stock of the California Institute of Technology for critical examination. A detailed account concerning this remarkable mold is to be expected as this study progresses.

With the establishment of this occurrence it is to be hoped that other animal molds will be found at occasional horizons. In fact, we anticipate the discovery of a petrified animal of some sort among the trees of the petrified forests.

While this paper has been contributed with respect to conditions within the Yakima Basalts, it is quite probable that the generalizations drawn hold for the basalts of the Deccan Plateau and for other plateau basalts as well. In summary it may be stated that fossils in basalts under proper conditions of surface water and in association with ellipsoidal structure are far from unknown.

REFERENCES

[1] Hereafter when molds are mentioned the related casts are understood to be included. The latter are extremely rare in Central Washington.

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NEW MUSEUM DIRECTOR

The Museum Board of the Eastern Washington Historical Society has selected F. S. Hall, former Assistant Professor and Director of the University of Washington at Seattle, to succeed the late Thomas A. Bonser as Director of the Public Museum of Spokane. Professor Hall came from Michigan to the University of Washington in 1909 and organized the museum there, remaining until the end of Dr. Suzallo's regime. In 1920 Prof. Hall organized the Northwest Bird and Mammal Society, of which he has been President continuously for sixteen years. He also started the "Murrelet," a magazine of bird-lore appearing three times each year. In the beginning it appeared in mimeographed form but has prospered and now appears as a neat magazine in print and half-tone illustrations. Professor Hall continues as its editor. In addition he is printing a series of biographical monographs of the early naturalists of the Northwest.

Northwest Science heartily welcomes Dr. Hall and can assure him he will be an appreciated addition to the group of scientists now making the Spokane region the center of their activities.

The Future Markets for Columbia River Power

H. V. CARPENTER
Dean of Engineering, State College of Washington, and Special Consultant on Power for Columbia Basin Study by National Resources Committee

Just why I should be asked to come before a group of scientists and act like a prophet is hard to imagine. Perhaps I am only expected to predict conditions 15 years ahead with the same type of cosmic accuracy that geologists use in locating dates 1,000,000 years ago.

First, let us see why we are excited about the power from the Columbia. The major power companies in Washington and in Northern Oregon and Idaho have an installed capacity of 1,112,000 kilowatts. By adding machinery alone they can increase this to 1,717,000. The new plant well under way by the army engineers at Bonneville, about 30 miles upstream from Portland, will add 432,000: the low dam at Coulee, 1,230,000; the high dam at Coulee would make a total there of 1,890,000; the development of the complete project for the City of Seattle and the plant ready to be built at the mouth of Flat Head Lake would add 696,000 more, making a total of 4,735,000 kilowatts installed capacity; or simply with Bonneville and the low dam at Coulee, 3,379,000; or with Bonneville and the high dam, 4,039,000. The fact that this latter figure is nearly four times the present installed capacity is the basis for so much consideration being given to the power market. The highest figure given can, of course, be doubled two or three times by the addition of additional plants on the Columbia, Pend Oreille, and other streams within the Columbia Basin.

It is evident, therefore, that if we are to make the most of our opportunity for development of the Northwest, we must devise ways and means for using this power for our own general well being. The possibility of absorbing this rather startling amount of power is not as hopeless as it may appear. During the decade 1920 to 1930, which by the way included two minor depressions and a substantial beginning of a real one, the average rate of increase of power consumption in this region was 9.5 per cent compounded annually, while the increase in population was less than 2 per cent compounded annually. During the recent depression the increase of use has been negative 3.5 per cent compounded per year, almost entirely due to business stagnation since domestic use has increased 58 per cent in five years and the domestic use is not a small factor since about 20 per cent of all power used and 35 per cent of all revenue comes from domestic customers. Prospective markets can be classified into domestic power use, commercial lighting, and small power, heavy industrial use, and reserve or secondary power uses. Domestic power use has been studied by a committee of the Northwest Resources Board and their report brings out the rather surprising fact that the investment in household appliances is so large that interest and depreciation on this investment amounts annually to about the same as the kilowatt hour charge, so that in studying means of promoting greater domestic use, cheaper and better appliances are highly important. A great deal of work is being done on this due in part to the impetus given by the Tennessee Valley Authority, with the result that we may hope for cheaper and more practical domestic equipment. This combined with prospective reduction in power rates may quite easily raise the domestic consumption to three times its present value in the next ten or fifteen years. Saturation exists in very few, if any, homes. Domestic use has shown a high resistance to the depression and should show a very rapid recovery from it. The house with the minimum

bill for electricity is one of the very best prospective markets, but the growth of this market depends upon better incomes for the family more than anything else. One of the best results of a new industry is to add population which becomes a market for power as well as a market for all other commodities and an added element of strength to the nation.

The homes of the Northwest are already using twice as much electricity as the average in the East, but very few homes could be considered saturated with the appliances that could be used there to an advantage.

Commercial Lighting and Small Power: This group will grow as the population grows although considerably more rapidly in normal times. The new trend toward improved ventilation, filtering, and air conditioning is likely to place this market on a considerably higher level. Electric ovens, furnaces, foundries, and small factories of all sorts will come with more population. This division of the market has been using about 20 per cent of the power in the past and can easily increase its percentage since our weakest link in the economic structure of the Northwest is our lack of small industrial concerns and their related activities and workers.

Heavy industrial users of power may be classified into two groups electrically. First, those in which power use is incidental and where power rates will have little effect on their establishment or success. Among these may be classified manufacturing in general, where power is used for light, motors, welding, ovens, furnaces, materials handling, and so forth; pulp and paper manufacture, lumbering, agricultural and horticultural processing plants, mining and concentrating, and certain of the electrochemical industries. This group constitutes in normal times and in the country as a whole the largest user of power. Promotion of these activities must be accomplished through other means than power rates, such as freight rate concessions, tariff protection, development of local mineral resources, and increase in population, thus providing better local markets. So far as local markets are concerned, a development of industries in a region is a cumulative affair. Each industry helps each of the others, thus leading to a growth following the compound interest law.

The other group of heavy industrial users includes those where the cost of power is vital because it is so large a fraction of the cost of operation. Examples of this group already placed in the Northwest or likely to find a place here are irrigation pumping, electrolytic deposition of zinc, copper, lead, and so forth, electric furnace metallurgy, magnesium, aluminum, ferrous alloys, and so forth, nitrogen fixation, and fertilizers, phosphate fertilizers, and many chemicals. These are the industries which should be more easily attracted to the region when cheaper power can be offered and, therefore, offer the most promising field for activity in promoting power use. Irrigation pumping can easily bring a very great development when and if agricultural prices return to normal. Electrolytic deposition of zinc, copper, and lead, together with their associated mining activities already are using some 500,000 h. p. in normal times and can be increased materially when markets justify. Lower rates for power will help considerably in this field, particularly in the production of zinc. The production of aluminum is almost dependent upon cheap power together with suitable raw materials which have not been found as yet in the Northwest. Research is being undertaken looking toward the production of aluminum from some of the splendid clay deposits of the Northwest, and is showing considerable promise. Magnesium, similarly, is dependent upon cheap power and for that we have the best deposits of raw materials, so that with the recent very rapid growth in the use of magnesium alloys, we should be able to develop a very substantial industry. Development of nitrogen fixation and the associated fer-

tilizer and chemical products together with phosphate fertilizers and the associated chemicals will likely depend upon and help create a combined chemical industry in which many by-products can be produced. Such developments have been begun at Tacoma, Trail, Anaconda, and Great Falls, but it seems quite certain that the development in this field is only nicely started. These industries classed as users of cheap power could easily develop in the Northwest to the point where they would use the greater portion of the power expected from Bonneville and Grand Coulee.

It is interesting, however, to look still further into the future. The Columbia should be made navigable at least to Lewiston, where careful surveys have just been completed, and to Wenatchee, and in doing this the amount of available power would be again doubled. Such a development can only be hoped for and uses for the power are not at present apparent, but we must remember that in the last 30 years the power demand in the Northwest has increased in this region from 45,000 kilowatts to 500,000; so why should you ask me what we will be doing 30 years hence.

There are, of course, certain reserve or secondary uses for electric power. Among these may be classified heating of residences, nitrogen fixation by the old arc method, off peak pumping for irrigation by storage, and off peak generation of steam. The last three are well-known methods of using power otherwise wasted. Residence heating can be done at a price which would just about repay the cost at the generating station. This leaves the cost of transmission and distribution to be provided for so that this use is hardly economic under present conditions, although use as auxiliary heating is growing, especially where rates are low. We are studying certain improved methods at Mason City but without any great hope of making it a thoroughly satisfactory market for power. The great argument in its favor is that all of the surplus power in the region could be used up in this way and by use of an auxiliary fuel heater for the coldest weather a reasonable load factor can be attained. Nitrogen fixation by the electric arc has been displaced by later chemical methods which consume much less power, but it is believed that under suitable conditions large blocks of off-peak power can be diverted into nitrogen fixation with some profit. There are many opportunities for using off-peak power to pump water into a storage reservoir to be used later for irrigation. These may be developed whenever the irrigated land is needed and the first cost for piping and pumps is not too great. Considerable off-peak power is already being used in the Northwest and elsewhere for producing steam for central district heating installations and otherwise and has proved advantageous where the steam can be produced and used without expensive transmission and distribution circuits, since it can usually be produced in large blocks without too great an initial investment. In many cases this is the best form for electrical heating to take, except, of course, the multitude of cases where heating is applied to some special purpose like cooking or hot water heating, where the comfort, convenience and cleanliness make it worth while.

* * *

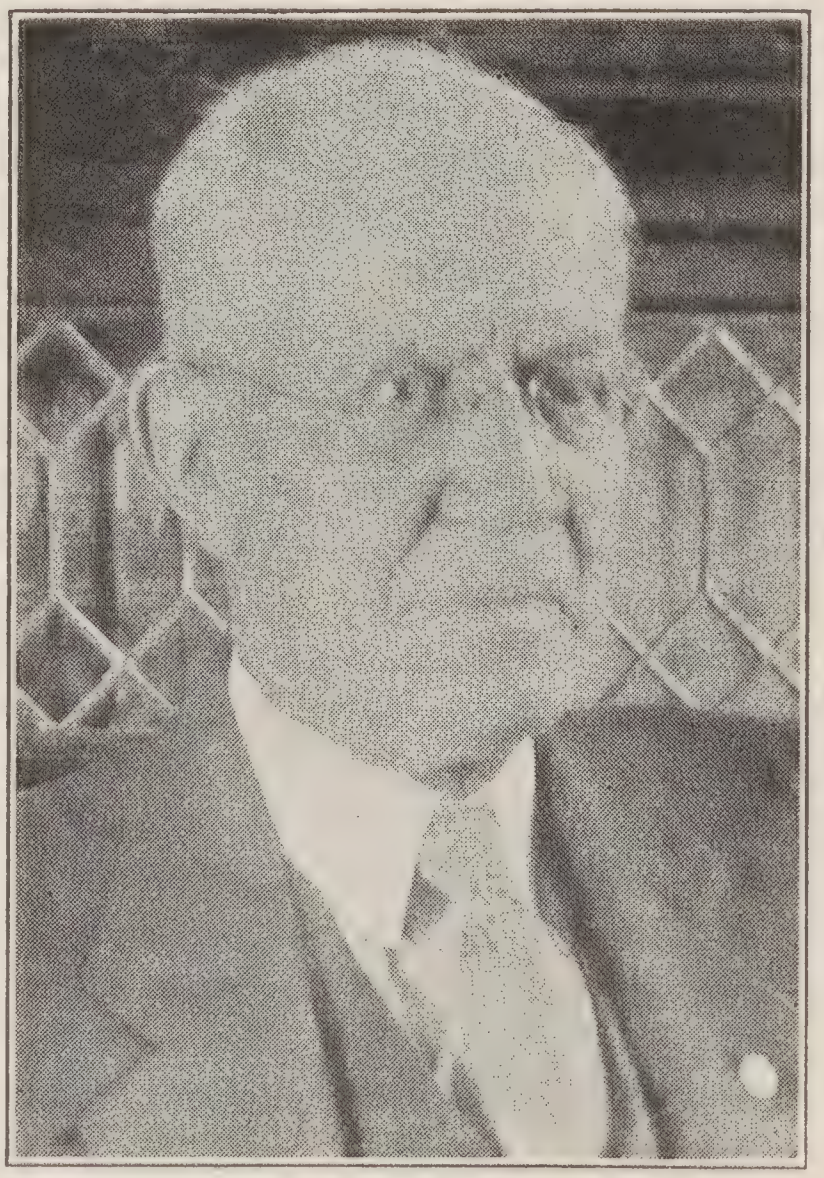
It is plain that the Northwest states should make every effort to insure useful application of as much of the power as possible and as promptly as possible. So, the question is, how shall we go about it to promote rapid development. It is apparent that every type of use is to be promoted and encouraged, but much of this is already being done. For instance, the utilities, both public and private, have been quite active in recent years in promoting the use of household appliances. In other fields of use we have not perhaps been so active. It will be admitted, I think, that our first move would be to examine the entire range of industrial

uses of electricity together with their dependence on natural resources, and the magnitude of each industry.

The location of the market for any product is important, particularly for us in the Northwest, where we are remote from the greater centers of population. After finding a few industries which look promising, each of these should be studied in detail. First, the markets, local, domestic, and export, keeping in mind competition at each market point and costs of delivery. Second, the processes used in production should be analyzed and the list of raw materials needed studied with determination of their cost and source and cost of transportation. With these factors in mind the most economic location for the industry should be determined based on location of deposits, type of transportation, available supplies of auxiliary materials, power, and labor. At this point it would be possible, on the basis of experience in older plants, to determine the costs at the plant and from this the cost at market centers. Such a study requires familiarity with the industry, a thorough study of the literature, and an extensive commercial analysis. All this before one is in a position to recommend the establishment of the industry. In some cases this work has been done by private organizations and the proposal abandoned, or it may be held in abeyance and the analysis kept secret. The possibility of special transportation rates for large tonnages of material and the influence of the size of the plant upon manufacturing costs together with uncertainties of labor supply, quality of raw materials and economic use of by-products all combine to make the study one requiring thorough analysis from both the technical and the commercial standpoints.

Frederic Keffer

Few men have had the variety and extent of experience in technology which has come to Mr. Frederic Keffer, veteran Mining Engineer and charter member of Northwest Scientific Association. In chemistry, geology, metallurgy, civil engineering, mine engineering, management and development, electrical engineering and electrochemistry, since his graduation from Ohio University in 1882, Mr. Keffer has done a bewildering variety of work and held positions of importance in Ohio, New York, New Jersey, Wyoming, Mexico, British Columbia. Immediately after graduation he was engaged on the Ohio Geological Survey. Two years following this were given to railroad construction. He then turned for two years to electrical engineering in Columbus, Ohio. For five years he was Associate Professor of Chemistry at his Alma Mater. This was followed by a period of three years when he was successively mining in Wyoming and



FREDERIC KEFFER

Mexico and in electrochemical work in New York and New Jersey.

With such preliminary experience he entered on his career as mine manager and developer in Western Canada. Starting with the Boundary Mines Syndicate, which was soon absorbed by the British Columbia Copper Company, he became General Manager of their smelter and their many mines at Greenwood. As geologist for the Company he explored the Copper Mountain properties at Princeton, where ore bodies amounting to fifteen million tons were located and proved. During his connection with this company between six and seven million tons of ore were mined and smelted with a smelter handling 2,000 tons daily. This product was being marketed in Germany. The outbreak of the World War closed these mines indefinitely.

Mr. Keffer was born in Philadelphia in 1861. His father was of German descent and his mother of French-Italian. He entered the Ohio State University at the age of fifteen years, graduating as a Mining Engineer in 1882. At Columbus, in 1888, he was married to Miss Emily Lehner, who died in Spokane in 1920. One son, Robert, was born to them. Robert Keffer, following in his father's footsteps, became a metallurgist and for some years was the chief chemist for the Anaconda Copper Mining Company, and was author of the widely-used "Methods of Non-Ferrous Metallurgical Analysis." He died in 1927. His son, Frederic Keffer, Jr., now lives with his grandfather, is a senior in the Lewis and Clark High School of Spokane, and is editor of the weekly publication of that school, the Lewis and Clark Journal.

Besides being one of the founders and a member of the Northwest Scientific Association, he is also a member of the American Association for Advancement of Science, the Canadian Institute of Mining and Metallurgy, the American Institute of Mining and Metallurgical Engineers, the Northwest Mining Association and the Spokane Chamber of Commerce. Twice he has been President of the Canadian Institute of Mining and Metallurgy, and in 1925 was elected Honorary Member, a distinction shared by only one other citizen of the United States, the Honorable Herbert Hoover.

Professional work takes Mr. Keffer into many of the Northwest States, California, Arizona, Nevada, and the Provinces of Canada. Younger men need look to their honors when on the trail or a scramble up a mountain-side with this veteran. At present he is consulting engineer and Acting President of the Columbia Mines Corporation, recently formed by amalgamation of a number of properties in Montana, Idaho and British Columbia. At their Midas Mine in Montana he planned and built the mining plant.

For some months past Mr. Keffer has been conducting a personal campaign to increase the membership of Northwest Scientific Association in the Provinces of Canada West.

W. N. Suksdorf, Pioneer Botanist of Washington[1]

F. L. PICKETT

Wilhelm N. Suksdorf was born September 15, 1850, in the village of Dranseau, Holstein, twenty miles southeast of Kiel, Germany. The family came to the United States in 1858 and settled in Davenport, Iowa. Wilhelm attended the public schools in Iowa and taught one year there. For two years, beginning in 1873, he was a student at the University of California. In 1875 he went to Bingen, Washington, where his family had settled while he was in California. In 1885 or 1886, at the invitation of Dr. Asa Gray, he went to Harvard College to study and to serve as a technical assistant. He returned to Washington soon after Dr. Gray's death in 1888. In 1924 he was granted a research fellowship by the State College of Washington which enabled him to spend a large part of two winters in taxonomic work in Pullman. In June, 1928, the State conferred upon him the honorary degree of Master of Science in recognition of his botanical work. He was run down and killed by a train near Bingen, October 3, 1932.

W. N. Suksdorf was a lover of plants and a student of plants. He became a collector so he might have material at hand to study, and so he might at the same time earn a livelihood and distribute desirable material to other students. He had been a student of plants in Iowa and California. He became interested in the flora of Washington soon after he went to Bingen in 1875. In the gorge of the Columbia River and in the adjacent country he found many forms he had never seen before, and that were not described in the available books. At that time there were few botanists in the Pacific Northwest who could help him, so he sent doubtful specimens to well-known botanists in other parts of the country and in Europe for study and identification. This brought him into touch with Dr. Gray and led to the invitation to work with him in Cambridge. It led to the acquaintance with many important taxonomists and to the contact with important herbaria that opened the way for the sale of his collections. Early in his work he came to know Thomas Howell, and added important material to Howell's first published list. Later he came in close touch with C. V. Piper and his work.

For several years Suksdorf did little botanical work other than collecting and studying plants. Later, he added to this work the collection and sale of seeds of promising forms for cultivation. During his last years he grew for dealers and the general market many native ornamental plants, especially those suitable for rock gardens. For this work and for the growth of doubtful species and varieties where they could be observed clearly, he developed a wonderful garden at his home, in which he could provide nearly all the natural conditions found in his area of collection.

In his private life and in his botanical work, Suksdorf was retiring and diffident. He never sought publicity, but rather avoided public mention. He had definite opinions, he was a keen observer, and he had developed a sound critical judgment, but he gave greater weight to the opinions of others. He was very sensitive to criticism, and was inclined to discount the value of his own work and opinions. Rather early in his work he developed an idea of species somewhat at variance with that generally current. His intensive study of certain small areas made him clearly conscious of the variations that are caused by, or, at least, correlated with differences of environment, i. e., the normal variability of species. As a consequence he was slow to accept slightly different forms when they were found growing under different conditions. Only after he

had grown them in his garden under identical conditions and found them constantly different would he consider closely similar forms distinct.

He was very slow to publish his work. His first publication did not appear until 1892, when he was forty-two years old. It was a catalogue of phanerograms and pteridophytes known to occur in the State of Washington, and was privately printed. Aside from the lists of plants of Oregon, Washington, and Idaho that had been published by Howell in 1884 and 1887, this was the first extensive list of plants of Washington. Something of its importance and historic significance are indicated by the fact that it was published almost a year before C. V. Piper began his work at the State College of Washington. This list contained a total of 1690 names, 1185 of plants that Suksdorf had collected in the two hundred square miles about Bingen and Mount Adams, 306 that he had collected in other parts of Washington, and 199 that had been definitely reported by other collectors. It was a splendid piece of work. His second publication, *The Flora of Mount Adams,* was prepared in cooperation with Thomas Howell and appeared in 1896. It remains the most complete list of the plants of the slopes and immediate environs of the mountain. Other papers appeared at irregular intervals, and were made up almost entirely of descriptions of new species and varieties. He published in all twenty-three articles, the last one just a few months before his death. At all times he was handicapped by his hesitancy about writing in English. Although he spoke English freely and accurately, he preferred to write in German, perhaps from the fear of petty criticism. This led to the use of German periodicals for many of his papers, and finally to his most ambitious enterprise, the founding of *Werdenda* in which his later articles appeared. Throughout his writing he was very careful. The last few months of his life were made almost miserable by the fact that his most important paper had been published with many mistakes. He had worked with the genus *Amsinckia* for years and then had spent every available hour through two years writing the manuscript. When nearly ready for publication he feared it could not be completed in time to avoid the new rule that required descriptions of new species to be in Latin, if published after January 1, 1932. The paper was printed and issued on December 31, 1931, but without being properly proof-read and corrected. It was followed later by a sheet of corrections and an index. Some may say that it was a foolish thing to do. Perhaps it was. Younger men do equally foolish things. Suksdorf could read Latin descriptions freely enough, but he did not feel able to write in that language well enough to be beyond criticism. His printer had not set up the material as rapidly as promised. The man was faced with the choice of allowing his work to appear without correction or of losing the results of years of work because of inability to publish as required by accepted rules. He chose the former.

Suksdorf was very fortunate in finding new forms. Up to the time of writing this account it has been impossible to determine exactly how many new species and varieties he collected. Aside from those listed in his monograph on the genus *Amsinckia,* in which he described one hundred ninety-two new species, about one hundred new forms from his collections are known. Most of these were described by other botanists. Many new species were named in his honor. One genus, *Suksdorfia* was so named by Dr Gray. He saw plants clearly, unbiased by preconceived ideas, and so he often saw what others did not. This is well illustrated by the following case. For years, following Piper's identification, students called the common *Olsynium* of eastern Washington *O. grandiflorum,* taking it to be the plant that had been described by Douglas in 1830. It seems not to have occurred to any one to question the correctness of the identification although hundreds of specimens had

been examined or passed upon. Suksdorf found, what no one before had noted, that the filaments were much wider at the base than in the form common about Mount Adams and along the lower Columbia. He also found that the one distinct difference was closely correlated with less clearly marked differences in size and color of flowers, shape of petals, and habit of growth. The outcome of Suksdorf's keen observation was the description of the new species *O. inflaum Skdf.,* a species that has been accepted as valid by all who are acquainted with the plants and the published description.

Working almost wholly alone, he sought neither publicity nor social recognition. He and the work he did in the little three-room house that served him as home and laboratory were better known and understood in Cambridge, Mass., New York, Washington, D. C., London, Berlin, and in many other botanical centers than in his home town of Bingen. Visiting botanists sometimes found it difficult to find him at home because so little was known of his work by his townspeople. Only during the last years of his life did the villagers come to understand in some measure that the little, old, stooped man who wandered about the hills in the summer and in the winter worked in the little white house at the foot of a wooded hillside a few rods from the highway, was their best-known citizen, their only "world citizen," in fact. His sets of Washington plants had been placed in nearly every important herbarium in the world. The meticulous care with which they had been prepared attracted the attention of the men who had occasion to work with them. He received inquiries from many workers and commissions came to him from taxonomic specialists for the collection of plants in which they were interested.

Few botanists ever come to know the flora of a favorite area more intimately than Suksdorf came to know the "small area of the State of Washington, about 40 by 50 miles in extent, including Mount Paddo (Adams) and the country south of it to the Columbia River, being bounded on the east and north by the Klickitat and Lewis Rivers, and on the west by the summits of the 'Chiquash' Mountains, a range immediately east of the Wind River."[2] Through at least forty summers, sometimes on horseback, more often on foot, he went over this area carefully studying every plant formation. So thoroughly did he do his work that later field men who have thought of working on the east slope of the Cascades in southern Washington have avoided as fruitless areas where he was known to have collected. He ascended Mount Adams many times, a few times alone, and he very early came to appreciate the extremely rugged eastern side. He was one of the first white men to visit the ice caverns near Trout Lake. In addition to the intensive study of this limited area he made short trips south of the Columbia into Oregon, and longer trips into other parts of Washington. In 1884 he made extensive collections in the Yakima Valley, making the trip from Bingen by way of Bickleton on horseback. In the summer of 1890 he collected between Seattle and Bellingham. He made frequent trips into the Palouse Country, and spent most of the summer of 1916 in the region about Spangle. Some idea of the extent of his collections is given by his serial field numbers which reached nearly 13,000. As he rarely took single specimens, but ten or more so he could use them for distribution, this means that he collected and cared for many more than one hundred thousand specimens.

Suksdorf's correspondence led to that most important thing to the man who has not access to a good herbarium, an exchange of specimens. In his earlier years the exchange included fungi, mosses, and lichens as well as vascular plants, although in later years it was limited almost entirely to the last group. He gradually built up, through his own collections that had been identified or verified by

other workers and by exchange, a working reference herbarium of approximately 10,000 specimens, certainly the best private collection ever brought together in the Pacific Northwest, if not, indeed, the best in all western North America! This collection, together with undistributed material and his library of botanical magazines and books, were, in accordance with his wishes and through the cooperation of his brother, Theodore, of Bingen, turned over to the State College of Washington after his death.

In the story of the development of knowledge of the flora of the Pacific Northwest the name of W. N. Suksdorf will always stand beside that of C. V. Piper, whom he admired, who was his friend, and who said of him in 1906, "Among the botanical collectors since 1860 none has done more to explore the flora of the State than Mr. W. N. Suksdorf of Bingen."[3] Such a tribute would have been even more fitting at the time of his death, after twenty-five additional years of productive work.

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Howard R. Flint

A grievous shock to his host of friends everywhere, in and outside the Forest Service, is the sudden death of Howard Flint.

Becoming ill while representing the Forest Service on an exploration trip of the U. S. Geological Survey and the National Geographic Society down the Salmon River, he was brought out by airplane to a hospital in Missoula on Sunday afternoon and passed away late in the afternoon of the following day, October 14.

Born November 4, 1882, at Herman, Minnesota, Howard R. Flint lived on a farm until he was 17 years old; then, until he was about 25 years old, he worked as carpenter, millwright, foreman, timber cruiser and scaler, while securing his preliminary education. He left the United States Steel Company in the Iron Range, Minnesota, where he was in charge of an experimental washing plant, to enter the University of Minnesota to fit himself for the Forest Service. He entered the Service as assistant ranger on the Minnesota National Forest in 1910, was later transferred to the Michigan National Forest, and then became forest assistant on the Hayden National Forest, Wyoming. Shortly afterward, he was assigned to the Wagon Wheel Gap Experiment Station and thence to the Bonneville National Forest. He left the Forest Service in March, 1915, to be superintendent of a large tie-manufacturing company at Wind River, Wyoming.

In June, 1917, he returned to the Forest Service as timber cruiser on the Flathead National Forest in Region One. His rise thereafter, up to Regional Forest Inspector in charge of fire control on all the National Forests of Region One, was but the beginning of a versatile career seldom

HOWARD R. FLINT

if ever equalled by any member of the United States Forest Service.

Howard Flint never "dabbled" in any subject. He was recognized by his associates as an authority in forest economics, soils, range management, silviculture, fire control, aerial photography, and wild life resources. Recognition of this broad scientific ability happily came during his lifetime, with his election to the presidency of the Northwest Scientific Association for the year 1933. His selection as representative of the Forest Service with the Geological Survey-National Geographic

party was additional acknowledgement of his outstanding ability in science. His published writings and manuscript reports on many subjects, all unusually well written, remain as valuable contributions in various fields of endeavor.

To those who were fortunate enough to know him well, the personality of Howard Flint will never die. His keen sense of humor, inexhaustible friendliness, absolute mental honesty, admirable courage, infinite capacity for taking pains, his practicability, dependability, loyalty, high ideals and high character will endure undiminished as inspiring examples. So many gifts to his fellow men are made by but few people.

He was a thinker, and a doer, a man among men, yet gentle, and a lover of all that springs from the earth.

M. H. W.

Northwest Scientific Association members in general, and the foresters and allied workers in particular, lost a real friend when Howard Flint was taken from us. Those of us who knew him intimately, feel his death as a very personal loss. To know him, was to love him.

W. A. ROCKIE.

New Devices for the Forest Fire Protectionist

DONALD N. MATTHEWS
Pacific Northwest Forest Experiment Station

Forest fire protection is going scientific. This statement is not a prophecy. It is a fact brought about by the relentless pressure of necessity. The fire protectionist is scanning the specialized knowledge that has been developing so rapidly in modern times in physics, chemistry, meteorology and mathematical analysis for principles and handy devices that will aid him in his job. The protection of timber resources from fire is a serious responsibility and in order to redeem it properly every field of science that may possibly have anything helpful to offer must be brought to bear upon fire problems.

It is with this thought of the need for focussing the basic sciences on the problems of fire protection that I wish to call attention to a few devices developed by the forest service in the North Pacific region. These devices were designed and built by young graduate physicists under the direction of foresters familiar with fire problems. Although actual use in the field has demonstrated their usefulness some of the instruments are still in the process of development because it takes years of use to uncover and correct defects in design and manufacture. From the standpoint of wide use by forest protection agencies it is desirable to have instruments that are extremely simple to operate and that are inexpensive.

Interesting features of the devices that I wish to present are the following:

The Haze Meter—Used by Lookouts in Rating Visibility.

The "Byram haze meter," so named in honor of its inventor, is based on the discovery that a smoke column is just visible to lookouts with good eyesight against a background approximately 60 per cent as bright as the sky at the horizon. It provides a simple mechanical means for finding some point in the field of vision that is 60 per cent as bright as the sky at the horizon. Once found, that point corresponds to the visibility distance in terms

of the lookout's ability to see a column of smoke at the same distance. All measurements correctly made with the haze meter are strictly comparable. One lookout's reading of a visibility distance of 10 miles indicates the same degree of haze as any other similar reading taken at any time or place.

The instrument is roughly "L"-shaped, about nine inches long, 1¾ inches square along the shank of the "L", and 1¾x3 inches at the foot of the "L". The small end has a sighting hole; the foot of the "L" is pointed in the direction for which a measurement is desired. Looking through the instrument, the observer sees a small colored bar superimposed on the field of vision. By means of neutral filters the brightness of this bar has been adjusted so that it corresponds to 60 per cent of the brightness of the sky at the horizon.

The observer directs this bar at a point a few degrees above the horizon. Then by slowly turning a mirror in the upper part of the instrument he brings up, opposite the bar, the reflection of first one ridge and then another. When a ridge approximately 60 per cent as bright as the sky at the horizon is reflected the bar disappears. The instrument is so arranged that when any ridge differing from the horizon bar brightness is reflected the bar becomes darker or brighter than the reflection. When the bar disappears, the observer notes which ridge appears opposite it. He then determines, with the aid of a map, if necessary, how far it is from his station to that ridge. The distance in miles is the "visibility distance," or the maximum distance at which he can expect to detect a smoke column of standard size in that direction at that particular time.

I might state in passing that this instrument is to me an outstanding demonstration of the possibilities of pure physics applied to an important fire protection problem. It is the result of several years of painstaking work during which many models were built and discarded principally because they were not suitable for use by the type of common labor mostly hired for lookouts. The haze meter has been tested and calibrated, using artificially produced smoke columns against timber backgrounds. In addition to measuring atmospheric conditions in terms of the visibility distance of a small column of smoke, it can also be used to measure haze, per se.

Fan Psychrometer.

A simple, friction-drive fan circulates air across the wet-bulb thermometer (as an improvement over whirling the psychrometer in the air). This type of instrument has several important advantages over the sling and rotary psychrometers: The probability of accurate readings is greater because the operator can watch the wet-bulb thermometer constantly and therefore is more likely to catch the lowest temperature indicated; it is easier to take readings, hence observers are more likely to make frequent measurements; and breakage is reduced to a minimum.

Relative Humidity Alignment Charts.

Checking some 17,000 relative humidity determinations made by fire guards during the past season in the usual manner, subtracting the wet bulb reading from the dry bulb reading and using a table, it was found that over 13 per cent were in error even after excusing all such mistakes as using the wrong tables. Some of these errors are very serious and result in relative humidity percentages that would be very misleading. Admittedly, all the errors could be eliminated by exercising closer supervision until personal carelessness had disappeared. However, it is a complicated process for untrained minds and right now we are looking to science for a simplified means of determining relative humidity from the wet and dry bulb readings. Mathematics in the hands of another physicist has given us an alignment chart that should be accurate to use because it involves no computations. It

remains to try it out in the field to see how the men react to it.

Scales for Weighing Fuel Inflammability Indicators.

A simple and accurate means for measuring those moisture content changes in forest fuels that indicate their inflammability condition has been needed for some time. This is still a fertile field for the application of principles from the pure sciences. However, there is one method finding considerable favor at the present time which involves exposing pieces of wood of known oven-dry weight to the elements and weighing them periodically to determine their current moisture content, which in turn is used as an indicator of fuel inflammability conditions. The weighing and computing incident to an ordinary moisture content determination is a real task for unskilled men such as are employed at many of the stations on the forests. By turning this problem over to physicists it has been possible to evolve a very practical scale that indicates accurately the moisture content of small pieces of wood of known oven-dry weight directly in the weighing process, thus doing away with all computations. Although at one time such an arrangement was said to be impossible, we now have two moisture content scales on one scale and so are able to weigh two sizes of samples on one instrument.

I have not covered the entire field of new instruments developed in recent months; indeed, I have not mentioned all that have been developed at the forest experiment station with which I am connected. There are, however, some other devices that might be mentioned briefly, including optically correct smoked glasses for forest fire lookouts bought by Region 6 last year on specifications drawn up and tested by the station, Osborne's transit cameras used to photograph oriented panoramas from lookout points so that other members of the organization, such as fire chasers, can see the country as the lookout sees it and so find fires more readily, and the recent phenomenal developments in light-weight radios for forest use. Both of the last two items are the product of the administrative organization in Region 6.

The Indian Trails and Their Uses[1]

HENRY L. TALKINGTON
State Normal School, Lewiston, Idaho

The Indians of this inland mountain section, sometimes termed the horse Indians, were great travelers. They went from one camas field to another, from hunting ground to hunting ground and from berry patch to berry patch and from tribe to tribe in their visitations.

Indian Trails Not Marked.

It is a long way from the trails and travois of the Indians to the modern highway, truck and auto, but the one represents the beginning and the other the latest in transportation. Most Indian trails in the United States have never, in so far as the author knows, been mapped, yet they have been of untold benefit to the explorer, the trapper, the missionary, the immigrant and the pioneer.

The Nez Perces were one of the largest and most progressive of the Indian tribes in the Northwest. They had trails leading in many directions: the Lolo, sometimes called the northern Nez Perce trail, one to the tribes in the Walla Walla country, another to the Spokane Indians and other nearby tribes, the southern Nez Perce trail passing through north central Idaho to Montana and northern Wyoming and still another along a route much the same as that of the North and South Highway from Lewiston to Weiser.

In general it may be said that in tim-

ler these trails follow the hog-backs and ridges, as less obstructions were found and there was less danger of ambush. They have been used by different people in the development of the Pacific Northwest and in this discussion the purpose will be designated.

The Explorer.

The Lewis and Clark Expedition stands almost alone in this class and the facts connected with it are too well known to need notice beyond its association with the Indian trails that afterwards became historically prominent.

Three Forks, the fur trading post, Fort Benton, the head of navigation on the Missouri River and the terminal of the Mullan Road, Helena and Virginia City of gold mining days are in all probability on an Indian trail between the Dakota Indians and those in the Rocky Mountains.

But this historic journey will forever be linked in its association with the Northern Nez Perce Trail (sometimes termed the Lolo Trail) because of the military expedition in the Nez Perce Indian War, the railroad surveys and the Lewis and Clark Highway.

For these reasons it seems justifiable to designate its route by naming the camping places of Lewis and Clark on their famous journey.

For these data the author is indebted to Mr. J. C. Harlan, a pioneer prospector and assessor of Clearwater County, who took a copy of the journals of Lewis and Clark and went over the routes designating the camp sites as follows: "Sept. 13, 1805, Lolo Pass; Sept. 15, a few miles south of the junction of Service and Cayuse creeks; Sept. 16, Howard camp; Sept. 17, Indian grave camp; Sept. 18, source of Bald Mountain Creek; Sept. 19, Fishcreek just north of Fish Butte; Sept. 20, near source of Dollar Creek; Sept. 21, Mud Lake; Sept. 22, just south of Weippe; Sept. 24, Orofino."

Missionaries.

Using Spalding as a center because of its geographical convenience, several trails may be mentioned in a general way. This place was connected by trail with the following missions: Whitman, Eells, and Walker, St. Maries, Kamiah and Pend Oreilles.

But on different occasions, the Indians from Northern Idaho and Western Montana met the missionaries at South Pass in western Woyming. These Indians must have used the trail up the Bitterroot River and on by Fort Henry and the Oregon Trail, or still others through western Wyoming.

Railroads—Early and Late.

The necessity felt by the government for a more thorough and satisfactory knowledge in detail of the geographical and topographical character of the country that lay between the Mississippi and the Pacific Ocean, looking especially toward the location and construction of a Pacific railroad, called into the field, in the spring of 1853, under authority of congress, several corps of engineers and explorers, whose mission it was to supply this desired information within certain limits of time and means. An old map issued by the national government in 1867 showing proposed route indicates how well this work was done as the Great Northern, the Northern Pacific, the Union and Central Pacific, the St. Louis and Santa Fe and Southern Pacific railroads followed in a general way the routes mapped out by these surveys.

Early Surveys.

But we are interested chiefly in the work of the northern corps, whose work consisted in finding routes across Montana, northern Idaho and Washington. This was in charge of I. I. Stevens and was very thorough. The report of his explorations and surveys were afterwards published in 12 volumes and contains many maps.

Governor Stevens (first governor of Washington Territory) was aided by Captain Mullan, who constructed the Mullan Road from Fort Benton, Mont., to Wallula, Washington, a distance of 640 miles. This may be termed the first highway in the Northwest.

The Northern Pacific and Milwaukee later made surveys along the Lolo Trail and the former along the Nez Perce or Southern Trail.

Nez Perce Trail.

The starting place of the regular Nez Perce Trail was either at Stites or Harpster on the south fork of the Clearwater, the two branches meeting at the present town of Clearwater. Here the trail turns almost due south to Corral Hill, then southeast to Mountain House, located between Bald Mountain and China Peak, continuing south to Bear Creek. From here the route is almost due east to the northwest corner of the township in which Elk City is located, diagonal through this to the southeast corner. The route continues south and up the Red River almost to its source. From here the trail runs almost due east crossing Bargamin Creek near its source, continuing eastward by Mount Magruder on the east side of which the noted packer by this name was murdered; a short distance east of this the trail crosses the Bitterroot Mountains at Nez Perce Pass and into Montana near the headwaters of Bitterroot River, which was followed by Lewis and Clark in their trip by the Lolo Pass.

Site of Magruder Murder.

One of the most interesting places to Lewiston people, on the Nez Perce Trail, is the site of the Magruder murder.

This is described as follows by a forester:

"About a mile and a half from where one crosses the Selway River near the mouth of the Little Clearwater, the old Nez Perce Trail, after following the crest of a craggy hog-back for some distance, widens out into a very beautiful little saddle, with quite large trees and grassy spots, a really nice place for an overnight camp on a trail that affords few camping places in this particular stretch. This is the place where Magruder camped and where in the night he was murdered and robbed."

A plaque has been placed on a large tree which reads as follows: "Lloyd Magruder Party murdered by road agents while on route to Lewiston, Idaho, from Virginia City, Montana, October 4, 1863."

The Mining Era.

Early in 1861 the Elk City mines were discovered by parties from Orofino and later in the fall the rich discoveries of Florence were made. It is quite certain that these miners from Pierce must have learned from the Indians something of the Nez Perce Trail and followed it from its beginning on the Clearwater to the new mines.

The richest of the mines at Florence, located just south of Elk City, were beyond a miner's dream. States a report of a miner at Florence: "The first day he worked on his claim, near Baboon Gulch, he took 57 ounces; the second day, 157 ounces; the third day, 214 ounces, and the fourth day, 200 ounces in two hours. According to one authority 20 to 25 thousand were on their way to these mines in 1862 and that year the yield of gold was seven million dollars."

Continuing south are Warren, another rich mining district, and still farther south the mines of the Boise Basin. While the early miners followed rivers they were never far from Indian trails.

Followed Old Route.

A placer mine is soon worked out, so the miners moved on up the Salmon River, always near the Nez Perce Trail. The town of Elk City had become a supply point reached by way of the trail mentioned. Stopping places were established as well as a mail route.

The Buffalo Hump mines were discovered in 1898 and the next year the North-

ern Pacific Railroad company made a survey, using the Nez Perce Trail as a basis, until they reached Elk City, then followed the Clearwater to Stites. But the travel to the new mines was on the old Miller Road by way of Adams Camp and then to Buffalo Hump and Orogrande. Yet the mail continued by the old route and Elk City.

Early Roads and Modern Highways.

The Mullan Road, begun in 1859 and finished three years later, is the first great highway in the Northwest. It started at Wallula, went east to Walla Walla and then north by way of Spokane, then east by way of Coeur d'Alene Lake and River, crossing the Bitterroot Mountains at Sohn's Pass, then down the St. Regis River to Missoula. From here to Mullan's Pass, where the road crosses the Rockies, the Hell Gate and the Little Blackfoot were followed. The road then turns north by way of Helena and then east almost paralleling the Missouri to Fort Benton, the headwaters of navigation, on this river, a distance of about 640 miles total distance from Wallula. Other early roads were Captain Frazier's Wagon Road, extending from White Bluffs on the Columbia to a point about midway of the route from the present site of Spokane to Fort Colville. The Colville Road began at Fort Taylor on the Snake to the Spokane River just west of the present city of the same name. About the same time the Meacham Road on the Oregon Trail over the Blue Mountains was built. Modern highway maps show so well the location of these roads it seems unnecessary to call attention to their routes.

Yet there are two highways, one complete and the other in the process of construction, that should be noticed. The former leads from Grangeville to Elk City and taps a large mineral belt where formerly were found some of the richest placer mines in the state and where now are supposed to be found quartz mines of great value. All of these are near the Old Nez Perce Trail. The latter, the Lewis and Clark Highway, follows the Lolo Trail and will when completed connect Lewiston and Montana at Lolo Pass. There are shipped annually from Lewiston and vicinity about 350 carloads of fruit and about 50 of vegetables or 400 in all. There are about 8 good truck loads for every car or 3200 in all. One prominent orchardist has been trucking by way of Spokane. This new highway would shorten the distance 137 miles and facilitate travel for tourists who come down from Glacier Park and turn thousands this way who otherwise lap back toward Yellowstone.

By the Spokane route, Butte is almost 100 miles farther from Lewiston than is Salt Lake but by the Lewis and Clark route the distance would be about 50 miles less than from Salt Lake.

In conclusion we may say whether explorer, missionary, immigrant, miner, road, railroad or highway builder, the Indian trail has been a big factor in pointing the way.

REFERENCE

[1] Presented at the annual meeting of the Northwest Scientific Association, Dec. 27-28, 1933. Spokane, Wash.

Notes on Oregon Liverworts

LAWRENCE E. GRIFFIN and ELEANOR THURSTON
Department of Biology, Reed College, Portland, Oregon

Good places at which to collect liverworts near Portland are near the waterfalls and along the trails of the Upper Columbia River Highway, especially at Multnomah Falls, Wahkeena Falls, and Eagle Creek. Other locations where many species of liverworts are found are Silver Creek near Silverton, along the Salmon River near Tawney's Mountain Home, along the South Fork of the Clackamas River near Camp Hillockburn, and in the vicinity of Mill City.

A few species either rarely found or not definitely located in Oregon are in our collection. *Bazzania ambigua* was found on rotten stumps along the trail at Silver Creek Falls, and also in virgin timber within a deep canyon of the South Fork of the Clackamas River. *Ricciocarpus natans* grows abundantly in swampy water near Oakgrove on the Willamette River, and in the sloughs of the lower Columbia River. *Riccia sorocarpa* is quite abundant in the open pastures on the slopes of Parrot Mountain near Newberg, and less plentiful on parking strips in Northeast Portland, on the banks of Mill Creek at Salem, and along the Columbia River Highway. Species found growing on rocky banks in the Spring, with fruiting bodies, include *Reboulia hemisphaerica* at Multnomah Falls, *Clevia hyalina* near the Main South Falls of Silver Creek, and *Preissia quadrata* along the Larch Mountain Trail a fraction of a mile below the Palmer Road crossing. *Aplozia lanceolata* was observed fruiting in February along the Salmon River near Tawney's Mountain Home.

Pellia epiphylla, as well as *P. neesiana,* has been found occasionally near Portland. *Jamesoniella automnialis* and *Calypogeia fissa* grow in many places in this vicinity, including Macleay Park, the Columbia River Highway, and near Estacada. *Scapania dentata ambigua,* or *S. undulata dentata,* as it is sometimes called, grows near the coast and along various mountain streams, including Multnomah Creek. The region around Portland offers endless opportunities for further collection. The *Scapanias, Madothecas, Calypogeias,* and *Anthocerotes* found here need special attention and study. In the immediate vicinity of Portland have been found the following species:

Anthoceros fusiformis Aust. — Macleay Park, Mt. Scott, Oswego Lake.

Blasia pusilla L.—Macleay Park, Berkeley Station.

Calypogeia fissa (L.) Raddi. — Macleay Park, Mt. Scott, Oswego Lake.

Calypogeia trichomanias (L.) Corda.—Macleay Park.

Cephalozia bicuspidata (L.) Dumort.—Macleay Park, Oswego Lake.

Cephalozia media Lindb.—Mt. Scott, Oswego Lake.

Conocephalum conicum (L.) Dumprt.—Macleay Park, Berkeley Station.

Jamesoniella autumnialis (De Cand.) Steph.—Macleay Park, Berkeley Station.

Lepidozia reptans (L.) Dumort.— Macleay Park, Oswego Lake.

Madotheca navicularis (L. and L.) Dumor.—Macleay Park, Reed College, Mt. Scott.

Marchantia polymorpha (L.)—Macleay Park, Reed College.

Pellia epiphylla (L.) Corda. — Macleay Park.

Plagiochila asplenoides (L.) Dumort.—Macleay Park.

Radula bolanderi Gott.—Macleay Park, Reed College.

Riccardia multifida (Nees) Lindb.—Oswego Lake.

Riccardia sinuata (Dicks.) Trevis.—Macleay Park.

Riccia sorocarpa Bisch.—Parking strips.

Ricciocarpus natans (L.) Corda.—Near Oakgrove.

Scapania bolanderi Aust.—Macleay Park, Mt. Scott.

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Printing of plates extra, at actual cost

NORTHWEST SCIENCE

FEBRUARY, 1936

Vol. X No. 1

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A journal devoted to the dissemination of scientific knowledge and encouragement of research in the Pacific Northwest

TO BE PUBLISHED IN FIVE NUMBERS IN 1936

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Entered as Second Class Matter, April 5, 1927, at the Postoffice at Cheney, Washington. Office of Publication, Cheney, Washington. Subscription Price to Members, Including Dues, One Dollar per Year; to Non-Members, One Dollar.
Volumes I. to IX., 1927 to 1935, Each $1.25

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-:- EDITORIAL COMMENT -:-

N. W. S. A. ANNUAL MEETING

Continued growth of Northwest Scientific Association was evidenced in the Annual Meeting for 1935. Both attendance and new membership showed decided gains. A number of fine papers given in the rejuvenated Bacteriology and Public Health section promise well for the future of that section. In all seventy-eight titles of papers appeared in the program in addition to symposia of two sessions each, dealing with Soil Conservation and with the forestry problems, forest pathology and forest land conservation.

A MEMORIAL TO HOWARD R. FLINT

A few weeks prior to his death, Howard Flint gave a sum for the support of research. Inspired by this gift and the proposal by Mrs. Flint that she continue such support yearly in honor of her husband's memory, a number of his friends has suggested the desirability of attempting to raise a fund, the income from which will be used as a permanent memorial. After conference in Spokane, announcement has been authorized of this attempt to establish such a memorial fund Major Evan Kelly Regional Forester at Missoula, will act as committeeman for those in the Forest Service and the Board of Trustees will announce the names of others on the committee representing all groups with whom Mr. Flint had contacts.

THE CONSTITUTION

Printing the Constitution of Northwest Scientific Association at this time will be welcomed by all new members and many of the older members who have not been able to keep up with the changes which have been made from time to time. It is hoped also that if the entire Board of Trustees know the provisions which are made to enable the rather large group to transact business as easily as a small group, it may find that it can function in many matters with much greater speed. While the Board of Trustees is for most practical purposes an independent body administering the affairs of the Northwest Scientific Association Corporation a non-profit corporation, it is expected to keep the membership of the Association informed of its activities through its annual report to the Council, to be presented by that body to the General Meeting. (Article VI., Section 7.)

PALEONTOLOGY OF THE COLUMBIA PLATEAU

One of the most interesting periodicals coming to the editor's desk is a mimeographed sheet by Prof. George F. Beck of the Washington State Normal School at Ellensburg, entitled GEOLOGICAL BULLETIN, W. S. N. S., Ellensburg. It is packed full of news of the Ginkgo Forest, fossil rhinoceri, bones of Pleistocene horse, tracks of Giant Sloth, four-tusk elephant, camel, etc. It is deserving of attention from those who wish to support live research in the region.

TWO SUMMER MEETINGS

Scientists in general will be interested in the coming meeting of the Pacific Division of the American Association for Advancement of Science in Seattle in June, announcement of which will be found on another page Teachers of Science will find an important meeting of the Science Section of the National Education Association in Portland, Oregon, in early July. This Section of the National Association is, this year, under the leadership of Mr. Ira C. Davis, formerly a teacher in North Central High School of Spokane. He is now in the University High School of Madison, Wisconsin. Mr. Davis and his associates in Wisconsin have presented some analyses of objectives to be attained in high school science instruction of interest well above that ordinarily offered in educational meetings. If he succeeds in pulling the program of this meeting up to this level it will be well worth attendance from this section.

NORTHWEST SCIENCE

VOL. X. FEBRUARY, 1936 NO. 1

The Association is not responsible, as a body, for the facts and opinions advanced in the papers published by it.

Soil Conservation as a Factor in Farm Finance[1]

By R. W. DORSEY[2]

The remarks that I am about to make are not to be considered as an official statement of the attitude of the John Hancock Mutual Life Insurance Co., or other farm mortgage companies, but rather my own statement, after having seen the widespread and in a number of instances alarming damage done by soil erosion in this section in the past few years, and an opinion of what in my estimation will probably be the effect upon the loan policies of lending companies.

Farm mortgages are based primarily upon the value of the security offered. This value is determined by the present producing power and the future potential producing power of the property that is offered as security for the loan. Secondary importance is attached to the financial solvency of the borrower but, nevertheless, the primary consideration is the value of the property offered and this value is largely determined by the present and future producing power of the property.

For years conservative mortgages on farms in good farming sections have been considered one of the best form of investment for trust funds, such as life insurance monies, for the reason that it was felt that regardless of what could happen the value of the property securing the loan would remain constant or increase. True, a financial panic might develop and temporarily the monetary value of the products of a farm might drop, but as soon as this temporary condition was alelviated, and prices of farm products came back to normal, the monetary value of a farm held as security for a farm loan would return.

Some types of farms, for example apple orchards, were not considered good security for mortgage loans because the future producing power of an orchard could be easily destroyed or impaired by poor management or a number of other factors. However, wheat farms in the better farming sections were supposed not to be susceptible to these adverse factors.

Now, considering the above facts, let us see what is happening. The best way to illustrate is to point to a specific case.

I have in mind a farm, a half interest in which sold for $50,000.00 in 1924, making an established value, at that time, of about $100,000.00 for the farm. In 1927 a mortgage company placed a loan on this property of $42,000.00, which was later reduced to $39,000.00. Gradually the producing power of this property became less, until the farm could not produce enough to pay interest and taxes and in 1934 the mortgage company was forced to foreclose. On acquiring possession this is what the company found: Of the 850 acres of tillable land on this farm 350 acres were so cut up by eroded areas, that it was impractical to raise grain on this land and the whole 350 acres have been planted to pasture in an attempt to save what soil remained. These eroded areas consisted of tracts, some as large as four or fice acres, from which all top soil and subsoil had washed, leaving only plain hard rock and gullies four to eight feet deep and about that wide cutting through the cultivated fields. The remaining 500 acres while damaged can probably be saved by an intensive soil building program, but if this is not done it will not be long

until it also will be in the same shape as the 350 acres.

I want to make this point clear—the primary reason that the mortgage company had to take this place was because its productiveity was badly impaired. If this farm had produced the same quantity of crops as it did 10 to 12 years ago the farm could have easily porduced enough in 1933 and 1934 to have paid the interest and taxes and left something for the operator. But in an attempt to get the last dollar from wheat, the stubble was burned and a system of intensive farming was practiced that produced for a few short years slight increases in yield but soon resulted in a condition that brought about a severe loss from soil erosion, which in turn cut the yield and this and not the depression, was the primary reason that this farmer lost his farm. True, the depression was a factor but is was not the primary cause. How long do you suppose this farmer could continue to pay interest and taxes even in normal times after practically destroying 350 acres out of 850 tillable acres on his farm and severely reducing the producing power of the remaining 500 acres?

I know that the natural reaction in a farming community is to feel sorry for the farmer who has lost his place. But take this case—should we feel sorry for this farmer? True, he lost his investment, but he lost it because he mined (not farmed) his farm for every dollar that he could get, and just as fast as he could get it, and in doing so almost destroyed a fertile, valuable farm and deprived the community and nation of the products that his farm should produce for a number of years. Perhaps there should be some sympathy for the mortgage company that loaned this man the money on his farm and now has to take it over and in order to protect its investment in the place must lay out an extensive soil conservation program.

If this were an isolated case it would be bad enough, but it illustrates a condition which exists in varying degrees on a large percentage of the farms in the Inland Empire. Many times the extent of the damage by soil erosion is not known by the farmers on the farms for the reason that the damage is gradually done and the farmer does not realize what is happening. I have seen farms all over the Palouse country, the Moscow, Lewiston, Nez Perce, Grangeville, Pomeroy, Dayton, Walla Walla and Pendleton sections and in every section there is severe erosion damage; true, not as bad as the case illustrated, but if something is not done the damage will eventually be perhaps even worse.

Just remember this: At the time these farm mortgages were made they were made at low interest rates on what was supposed to be absolutely safe security. When this outside money came into the community it acted as a buffer and enabled a number of farmers as well as banks and business houses to weather temporary difficulties. This money in the main represents the small savings that fathers all over the country have deposited with these life insurance companies to take care of their widows and children when they pass on. These trust funds must and will be preserved.

Now, keeping the above facts in mind, I want to ask you a question or two. Say that you are on the finance committee of a large life insurance company and that you know of one or several cases of severe erosion damage in some section. An application for a new loan from that section is up for consideration.—How would you vote? Could you be certain that this farm on which a new loan was being considered would not in a few years start washing and the company sustain a severe loss? Or say a loan comes up for renewal from a section that is sustaining erosion losses or on a farm on which erosion is already starting, would you not insist as a condition of renewal that substantial principal payments be required? Now I want to ask you: Say that all of the life insurance

companies should take the same attitude, what would it mean to the farming community involved?

I have lived in an agricultural community that in former years was the center of a prosperous district. Due to local conditions, outside investors lost confidence in the locality and outside credit was withdrawn. I saw the results—wholesale insolvency among the farmers, every bank in the county broke, mercantile establishments that in former years were considered in excellent financial condition broke and closed by creditors, every individual in the community adversely affected either directly or indirectly.

I do not believe that the erosion damage has reached sufficient volume at this time to affect outside credit in the sections referred to. Nevertheless, if this damage is not controlled, it will most certainly eventually affect the attitude of outside investors. It is to the advantage of every farmer, merchant, banker or individual dependent directly or indirectly on the farming community to stop this soil erosion before it does affect outside credit and brings about a financial breakdown in his community.

[1] Presented at the Meeting of the Northwest Scientific Association, Spokane, Washington, December 27-28, 1935.

[2] Farm Inspector for John Hancock Mutual Life Insurance Co.

Seattle Meeting of the Pacific Division, A. A. A. S.

J. MURRAY LUCK
Secretary, Pacific Division, A. A. A. S.

The twentieth meeting of the Pacific Division, American Association for the Advancement of Science, and affiliated organizations, will be held at Seattle under the auspices of the University of Washington. The period, June 16 to 20, has been approved as the time of the meeting and the requisite local committees have been established to supervise arrangements. The general committee established by the University of Washington consists of A. F. Carpenter, Chairman; E. R. Guthrie, Secretary; H. C. Allen, W. L. Beuschlein, B. H. Christian, G. E. Goodspeed, B. L. Brondal, J. E. Guberlet, D. H. Loughridge, C. E. Magnusson, R. C. Miller, T. G. Thompson and E. B. Stevens. Eighteen of the affiliated societies representative of all branches of science are preparing to participate in the meeting. A symposium on the general subject of Oceanography is in process of organization. It is expected that these papers on Marine Biology, Physical Oceanography, Fisheries and Hydrographic Survey will be presented as the principal addresses within the general symposium. Three evening addresses of special interest to the general public will be presented by distinguished scientists. An afternoon will be devoted to the progress of research in which recent developments in astronomy, chemistry, botany and paleontology will be discussed. The concluding three days of the meeting will be devoted to scientific sessions of the participating organizations and excursions and field trips to places of scientific interest. It is estimated that six hundred members of the Association and affiliated societies will attend the meeting. A Preliminary Announcement containing detailed information will be widely distributed in March. Members proposing to present papers are advised that titles and abstracts must be submitted to the secretary of the society concerned not later than April 25. All inquiries pertaining to local arrangements should be addressed to Dr. A. F. Carpenter, Department of Mathematics, University of Washington.

MONTANA NOTES

Dr. H. W. Scott, Montana School of Mines, has been making extensive studies on the Montana earthquake, and will publish a paper on it shortly.

Another report on Montana groundwater, this one on southeastern Montana, by Dr. Eugene S. Perry, will be issued by the Montana Bureau of Mines and Geology this month.

Grants-in-Aid of Research

Announcements appearing in the September and November issues of Northwest Science have apprised our readers of the arrangement for grant-in-aid from funds of the American Association for Advancement of Science to member or members of the Northwest Scientific Association, and of the stimulus of this grant in securing the sum of $100 from subscriptions by members of our Association. The action of the Board of Trustees in allotment of these funds was announced at the General Meeting, December 28, 1935, by Mr. R. H. Weidman, Chairman of the Board. They are as follows:

To Prof. Albin G. Matson, Bacteriology Department, University of Montana, the A. A. A. S. fund of fifty dollars for aid in study of the "blood groups" among the Indians of the Flathead Reservation; to Dr. Harold P. Klug, Chemistry Department, University of Idaho, seventy-five dollars for construction of an instrument for continuous recording of the differential thermo-couple galvonometer readings by photographic method, in the researches now in progress at Idaho on "Molecular Rotation in Solids"; to Professor J. H. Ramskill, School of Forestry, University of Montana, for continuation of study of geographical strains of seeds of *Pinus ponderosa* for adaptability to new environmental conditions and for study of significant differences in leaf-structure.

At the editor's request each recipient has submitted for publication a brief statement of the work in progress in each case. This seems one of the most auspicious events in the history of Northwest Scientific Association and can by no means be measured by the meagre sums now distributed. From the December meeting of the A. A. A. S Secretary Freeman brings word that the grants from that organization will be continued in the future. Elsewhere appears another announcement concerning funds for research.

Dr. Freeman, as delegate to the A. A. A. S. from N. W. S. A., reports further on page 19.

Dr. Klug's Project

MOLECULAR ROTATION RESEARCHES AT IDAHO

Recent studies, both experimental and theoretical, have shown that molecules, ions, and other atom groups in the crystals of certain solids are rotating or spinning above certain minimum temperatures. This minimum temperature where the transition to rotation occurs is in many cases below room temperature. The transitions can be located by various types of thermal studies, since energy is required for the rotation and a certain definite amount must be absorbed at this point.

Up to the present the experimental data on this phenomenon have largely come as incidental findings of investigations made primarily with another objective in view. In this laboratory we have recently undertaken a systematic study of ammonium salts and crystalline hydrates for these rotational transitions. The method is a thermal one in which the warming and cooling curves of the substance are studied by a differential thermocouple method. The sample is compared with a neutral body, known to show no transitions in the temperature range being investigated, by inserting one junction of the differential thermocouple in the sample and the other in the neutral body. The sample and neutral body are then warmed up or cooled down at a uniform rate through the temperature range being studied. The differential thermocouple is connected directly to a sensitive galvonometer, differences in temperature of its two junctions being read as a deflection on a scale at a

distance of a half meter. As long as the two junctions are at the same temperature the galvonometer deflection is constant. At the transition point the sample momentarily stops warming up or cooling down while the heat of rotation is absorbed or given off. This causes a deflection of the differential thermocouple galvanometer and a break in the curve obtained by plotting deflections against time. At the same time readings of a temperature thermocouple in the sample are being taken with a type K potentiometer.

The grant from the Northwest Science Association will be used to build an instrument for continuous recording of the differential thermocouple gavlanometer readings by a photographic method. This is highly desirable in order to locate with the greatest accuracy just where the transition occurs.

HAROLD P. KLUG.

Professor Matson's Project

Recent observations[1,2] have revealed that the distribution of the four Landsteiner blood groups is vastly different among the Blackfeet and Blood tribes of Indians than is their distribution among other Indian tribes. In the Blackfeet and Blood tribes the percentage incidence of group A was found to be comparable to the high percentage incidence of group O among other Indians. Until very recently, however, this study has been limited to but one set of factors—the four blood groups. Other constitutional blood characters, the factors M, N and P and the subgroups A_1 and A_2 and also the peculiar taste reaction to para-ethozy-phenyl-thiourea have been shown to exhibit characteristic racial differences. Obviously racial investigations of all these properties may yield data of anthropological significance. Although a preliminary report[3] has been made recently on the incidence of the M factor among the Blackfeet and Blood tribes, no such study has been made among the Indians residing on the neighboring Flathead Reservation. A study of the blood of the Flathead Indians with respect to these hereditary factors as well as the distribution of "tasters" and "non-tasters" among them is therefore to be undertaken.

[1] Matson, G. Albin. Proc. Soc. Exp. Biol. & Med., 30, 1380, 1933.

[2] Matson. G. A. and Schrader, H. F. Jour. Immunol., 25, 155, 1933.

[3] Levine, Philip, Matson, G. A. and Schrader, H. F. Proc. Soc. Exper. Biol. & Med., 33, 297, 1935.

Professor Ramskill's Project

The project involves a cooperative study between the Northern Rocky Mountain Forest and Range Experiment Station, of the U. S. Forest Service, and the School of Forestry, of the State University of Montana, concerning the adaptability of 22 widely scattered geographic strains of *Pinus ponderosa* for planting near Priest River, Idaho.

The material for study has been obtained from a plantation from seed from these sources made at the Priest River Forest Experiment Station about twenty years ago. The Experiment Station has assumed the task of studying gross dendrological differences of the young trees, most of which are now 15 to 25 feet tall. The School of Forestry has agreed to determine if the leaf structure of the different strains shows differences comparable to external variations, which will be checked against the leaf structure of material from the localities where the seed for the plantation was originally obtained.

In addition to assisting in determining adaptability to new environmental conditions of the seed strains involved, it is believed that the leaf structure study may reveal new facts, which may or may not support the belief of many botanists and foresters, that the name *Pinus ponderosa* is applied to two quite distinct forms, the *Scopulorum* form of the Rocky Mountains and the *Ponderosa* form of the West Coast.

Some Relationships Between the Soil Canyons of Certain Southeastern Washington Valleys and Summer-Fallow Cultivation

By JOHN P. THOMSON[1]

INTRODUCTION

The term "soil canyons" is used to designate the winding, vertical-walled trenches that carry the present drainage and which dominate the topography of many farm and range-land valleys in southeastern Washington. This statement of location does not restrict these features thus definitely; rather, it indicates a type area in the general Northwest region.

Many of the valleys which were eroded in the Columbia lava plateau are now marked by practically flat alluvial deposits which vary from 8 feet to 50 feet in thickness.

At present these deposits are undergoing rapid change due to accelerated runoff and erosion.

LOCATION OF VALLEY FILLS

The particular valleys and their soil canyons of which this paper makes note are as follows:

Pataha Creek, which drains from Pomeroy westward to Starbuck and the Snake River;

Deadman Creek, which roughly parallels Snake River, entering it at Central Ferry;

Johnson Creek, entering Kittitas Valley eight miles east of Ellensburg;

Alkali Flat Creek, which heads near Dusty and enters the Snake from the northeast at Riparia;

Willow Creek, a westward-flowing tributary of Palouse River, which has its source in the hills south of LaCrosse;

Rebel Flat Creek, that heads in the Endicott country and flows west, joining Palouse River at Winona;

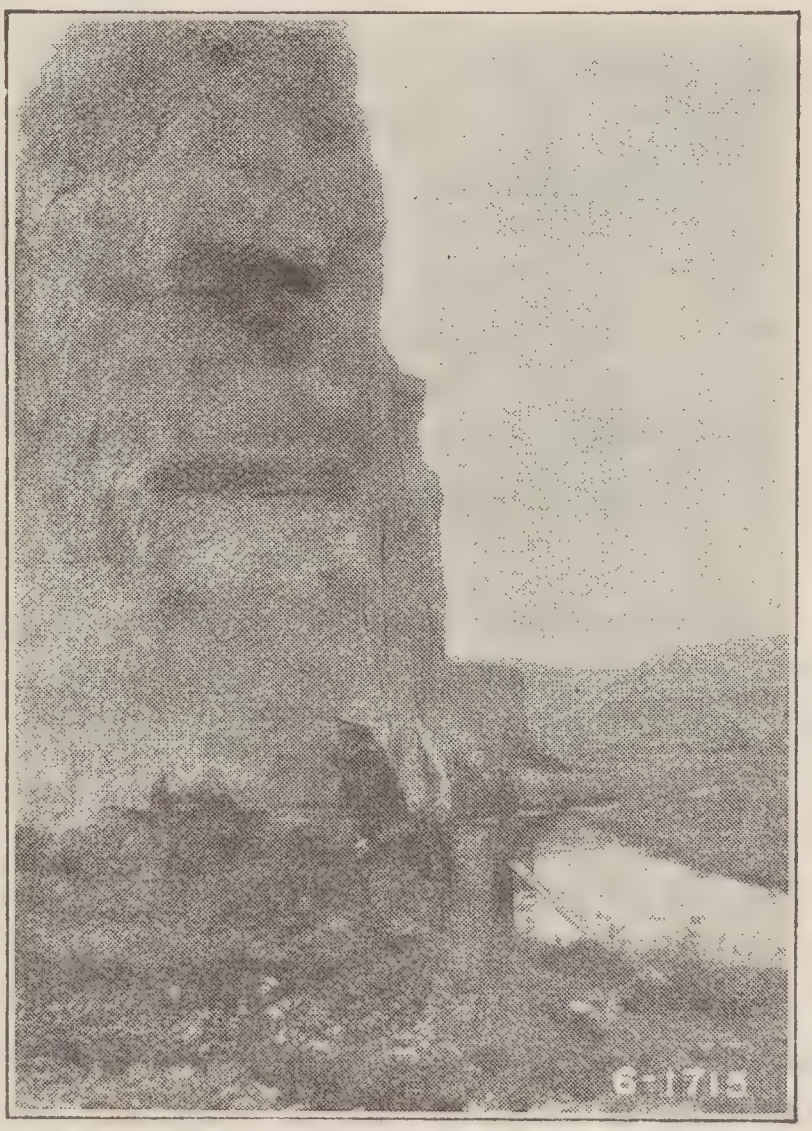
Meadow Gulch Creek, which flows northwest to Snake River at Central Ferry from the area five miles north of Pomeroy.

GENERAL DESCRIPTION OF DEPOSITS

There is marked similarity over large areas in the manner of location of alluvial fills in any particular valley. The sharp line at which these flood plains meet the canyon sides is especially striking.

Practically no alluvial fans or accumulations of like nature occur on top of the valley fills.

Soil canyons investigated to date display abundant evidence in support of the assumption that they bottom on pre-valley fill water courses at bedrock.



Looking upstream on Alkali Flat Creek, southern Whitman County.

Cut banks in the various canyons consist of both massive and moderately thin beds of silty alluvium, and in some cases beds of gravel and boulders. The occurrence of ashy appearing material in a definite whitish stratum near the top of

soil-canyon walls is widespread.

Remains of vegetation occur throughout the vertical extent of practically all soil canyon walls.

Dr. R. L. Lupher, Professor of Paleontology, Washington State College, has collected fossil bones from many of the cut banks in the Palouse region.

Another feature common to these flood plains is the presence of old shallow stream courses that occur scattered over the valley surface as remnants which in all cases carry a strong suggestion of different run-off conditions in the not-too-distant past.

The greatest likeness to be found in the valley deposits is that practically all of them contain the present drainage in deep shifting bedrock trenches, fed from watersheds which abound in one or both of the common present-day evils—summer-fallow cultivation and overgrazing.

Such points as differences in stream gradients and in proximity to master streams which might have caused backwater are mentioned as dissimilarities of soil canyons and the flood plains which enclose them.

SOUTH FORK OF PALOUSE RIVER

The South Fork of Palouse River was chosen for a discussion of soil-canyon details as it is representative of those viewed to date and because of the writer's better acquaintance with its history.

The South Fork of Palouse River rises in the Moscow Mountains east of Moscow, Idaho, and swings in a half-circular course to the basalt canyon near Pullman, which it follows to its confluence with the Palouse at Colfax.

Practically the entire watershed of the stream is characterized by the rolling hills of the Palouse country that rest directly on the basalt and granite bedrock or in some places, on a thin, iron-cemented basaltic or granitic alluvium which covers bedrock at verying depths and is termed here the Ringold formation.

GEOLOGIC HISTORY

NORMAL EROSION

The writer recognizes the following steps in the Pleistocene geologic record in southeastern Washington:

1. Normal erosion of the granitic highlands and basalt plateau in pre-Palouse time, with resultant formation of the Ringold.
2. Deposition of the Palouse formation.
3. Erosion and deposition — during scabland time.
4. Accumulation of extensive flood plain deposits.
5. Initiation of removal of these unconsolidated valley silts.

Except for step No. 3, the deposits of scabland time, the foregoing events all represented in the geologic record of the Palouse flood plain.

Of particular interest is the problem of conditions of deposition of the valley silts which comprise flood plains whose major features are comparable from Ellensburg to Central Ferry. However, a consideration of the genesis of flood-plain alluvium lies beyond the limits of the present paper and aside from showing a few pictures which display certain stratigraphic features and a brief discussion of eight alluvial samples, no time will be taken for this subject.

ACCELERATED EROSION

Beginning immediately with the cultivation of the "bunchgrass watersheds," a change came to the quiet drainages which meandered through the moist valleys. Many of them supported stands of wild hay and marsh grass in addition to their usual prairie-grass carpet.

Gradually, changes occurred in the demands made on a particular stream by its watershed, due to the fact that more water was supplied in a shorter time.

Nature is an abundant provider. In all ways, it appears that she is extravagant in assuring that vital processes shall go ahead in spite of serious disorders. So it was with the early streams in the area under consideration. Their protective cover

was greater than that which was needed for ordinary conditions of run-off. These streams might even now be flowing in shallow courses had their grassy channels been maintained, even though vast areas of their watersheds were transformed into "tin roofs" by summer-fallow cultivation. Instead of being maintained, the protective covering was destroyed. Wounds occurred where travel concentrated to cross creeks before the days of bridges. At other points, landowners, dissatisfied with a soggy, meandering channel, ploughed furrows straight along fences and roads, into which creeks were diverted.

Such abuse was more than Nature could heal unaided, when combined with the great changes wrought in these stream watersheds.

Normal erosion turned to accelerated erosion; stream channels were marked by waterfalls or heads which advanced upstream even through sodded channels that had not been injured—advanced by undermining and caving, until today most of our main valleys are marked by deep, vertical-walled canyons!

Looking up through a well from a point in the canyon wall at surface daylight. Note old water marks bearing mute testimony of water table levels of pre-soil canyon time.

Many of these deep defiles have reached bedrock and have established gradients. In some instances in regions of adequate rainfall, vegetation is again taking hold to control erosion. But what of the water table of the valley and what of the tributary drainages that enter the deep soil canyons? Here, again, waterfalls are formed which recede ever back into the flat valley or the sloping wheatfield. Tributary drainages entering these side flows also dig deeper, and thus an erosion cycle is thoroughly established.

It is interesting to note that the tremendous amount of soil removal known to have taken place on these watersheds has not made appreciable deposits in the lowlands, since cultivation began. Instead, the majority of main streams in these eroding areas display deep, rapidly widening soil canyons.

CONCLUSION

The events discussed in this paper may be summarized as follows:

1. There existed in the region of the soil canyons youthful pre-silt stream valleys.

2. These valleys were subjected to conditions of deposition which built flood plains distinguished by:

   a. Massive, even-textured strata.
   b. Abundance of enclosed vegetative remains.
   c. Absence of coarse alluvium.
   d. The lithologic similarity of valley accumulations over great distances in the Northwest.
   e. The gradual uniform regional erosion which the flood plain deposits suggest.

3. Summer-fallow cultivation and destruction of the protected valley channels initiated accelerated erosion, because streams were required to handle more water and handle it in a shorter time than before.

4. This condition has produced en-

trenched channels which mark the inauguration of an erosion cycle that bids fair to completely re-excavate, by shifting soil canyons cut to bedrock, many old valleys.

ANALYSIS

Soil Canyon Samples

Willow Creek No. 1
- 10% ash
- 65 quartz and feldspar
- 20 ferro-magnesian minerals
- 5 shreds of organic material

sub-angular grains .03 to .15 mm. slightly decomposed

Willow Creek No. 2
- 15% ash
- 65 quartz and feldspar
- 10 ferro-magnesian minerals
- 10 shreds of organic material

sub-angular grain size .02 to .1 mm. ash is decomposed

Willow Creek No. 3
- 70% ash
- 10 quartz and feldspar
- 15 ferro-magnesian minerals
- 5 shreds of organic material

sub-angular grains .02 to .1 mm. some pumice to .25 mm. ash de-
some pumice to .25 mm. ash decomp.

Willow Creek No. 4—White Layer
- 85% ash
- 10 ferro-magnesian minerals

sub-angular grain size .02 to .05 5% up to .15 fresh

Rebel Flat Creek—White Layer
- 95% ash
- 5 quartz and feldspar

angular grain size average .03 mm. fresh

REFERENCES

[1] Assistant in Research, U. S. Soil Conservation Service, Region 11, Pullman, Washington.
Paper presented before the Northwest Scientific Association, Spokane, Wash., Dec. 27 and 28, 1935.

Constitution of the Northwest Scientific Association

(WITH AMENDMENTS)

(Arranged by E. M. Keyser)

ARTICLE I.

NAME AND HEADQUARTERS

This society shall be known as the Northwest Scientific Association and the headquarters shall be at Spokane, Washington.

ARTICLE II.

OBJECT

The object shall be the promotion of scientific research and the diffusion of scientific knowledge.

ARTICLE III. (As Amended December 28, 1928)

MEMBERSHIP

Membership in this organization shall be divided into the following classes:

(1) Member. Any one interested in the purpose of the society may become a member on the annual payment of one dollar.

(2) Institutional Member. [a] State Universities, colleges and similar educational institutions. Annual dues $25.00. [b] Normal schools, other educational institutions and professional organizations. Annual dues $10.00.

(3) Life Member. Life membership may be obtained on the cash payment of $25.00, or by paying $6.00 per year for five years.

(4) Supporting Member. Supporting membership may be obtained by a minimum payment of $100.00.

(5) Patron. Persons contributing $1000 00 or more to the Association shall be known as patrons.

ARTICLE IV.

OFFICERS

The officers shall consist of a President, a Vice President, and a Secretary-Treasurer.

All officers shall be chosen by ballot on nomination of nominating committee or from nominations made on the floor at the Annual Meeting. Officers shall hold office for one year or until their successors qualify.

ARTICLE V. (As Amended December 29, 1932)

COUNCIL

The Council shall consist of the officers and five other members to be elected by the members present at the Annual Meeting.

Section 1—Duties: The duties of the Council shall relate chiefly to conduct of meetings of the Association, the publication of programs, proceedings, journals or other publications of the Association and to other matters relating to the functioning of the organization as an active scientific body.

Section 2—Interim Powers of Council: The Council shall represent the Association between regular sessions in all matters not specifically delegated to the Board of Trustees.

Section 3—Review of Trustees' Report: It shall be the duty of the Council to carefully review the Annual Report of the Board of Trustees and to present this report to the general meeting of the Association, with recommendations.

Section 4—Council Not Limited in Initiative: Nothing in this amendment shall be construed to limit the initiative of the Council in matters to be presented at the general meeting of the Association.

ARTICLE VI.

(As Amended December 29, 1932)

TRUSTEES

Section 1—Number and Classes: The Board of Trustees shall consist of eleven (11) members, of three (3) classes; six (6) members shall be elected from the active membership of the Association to serve for a term of three (3) years and chosen for their understanding of the nature of research problems, activity in scientific research or general ability in guidance of the conduct of research; three (3) shall be elected for a term of one (1) year on the nomination of the Board of Trustees to serve as the Executive Committee of the Board at such times as it is not in session: two (2) shall be selected by the nine trustees from the citizenship of the region served by the Association without regard for membership in the Association, but who shall become honorary members on election. Honorary members shall be chosen for interest in scientific research, and for recognized ability in public affairs. Following the first election after adoption of this amendment, the President and Secretary shall, by lot, divide the trustees into groups to serve one, two, and three years. Thereafter all Trustees, except the members of the executive committee shal lbe elected for terms of three years. Vacancies in the Board of Trustees shall be filled for unexpired terms by election for such term at the general meeting of the Association.

Section 2—Custodians: The Trustees shall be custodians of all real property of the Association and all other property and funds belonging to it, except such as shall be held by the Council and the Secretary-Treasurer for the immediate functioning of the Association as an active scientific society.

Section 3—Organization: The Trustees shall immediately, upon election, meet, organize, nominate to the general meeting an executive committee and adopt rules of procedure.

Section 4—Bond: The Trustees shall furnish such bond as the Council shall decide, the expense of the bond being paid from funds of the Association.

Section 5—Announcements: At the earliest feasible time the trustees shall make known to the public the provision which has been made for the safety of the funds which may be entrusted to it. They shall also make known the purposes of the corpoartion and the services it is prepared to render.

Section 6—Solicitation of Funds: The Trustees may, at their discretion, through the public press or by direct solicitations from individuals or organizations, call attention to the need of funds from other sources than public taxation for the prosecution of scientific research, the publication of the results of research, or the preservation and use in museums and libraries of materials, manuscripts and books, for the prosecution of long period research problems, and, for research programs of importance which extend beyond political boundaries for which legislatures may not make appropriations.

Section 7—Right of Initiative: The Trustees share with the Council the right to take initiative for policies furthering the interests of the Association, but the Trustees shall make a report to the Council of their activities at least a month prior to the general meeting of the Association.

Section 8—Cooperation: The fixed policy of the Corporation shall be friendly cooperation with existing institutions of the region served and particularly with member institutions. This provision shall be interpreted to include the various Federal and State bureaus, surveys, and services which are engaged in scientific work as well as educational institutions.

Section 9—Eligibility to Other Offices: Trustees may hold any office in the Association except membership in the Council.

Notes on the Sturgeon of the Snake River

(*Acipenser transmountanus.* [1] Family—Acipenseridae, White Sturgeon, Columbia River Sturgeon)

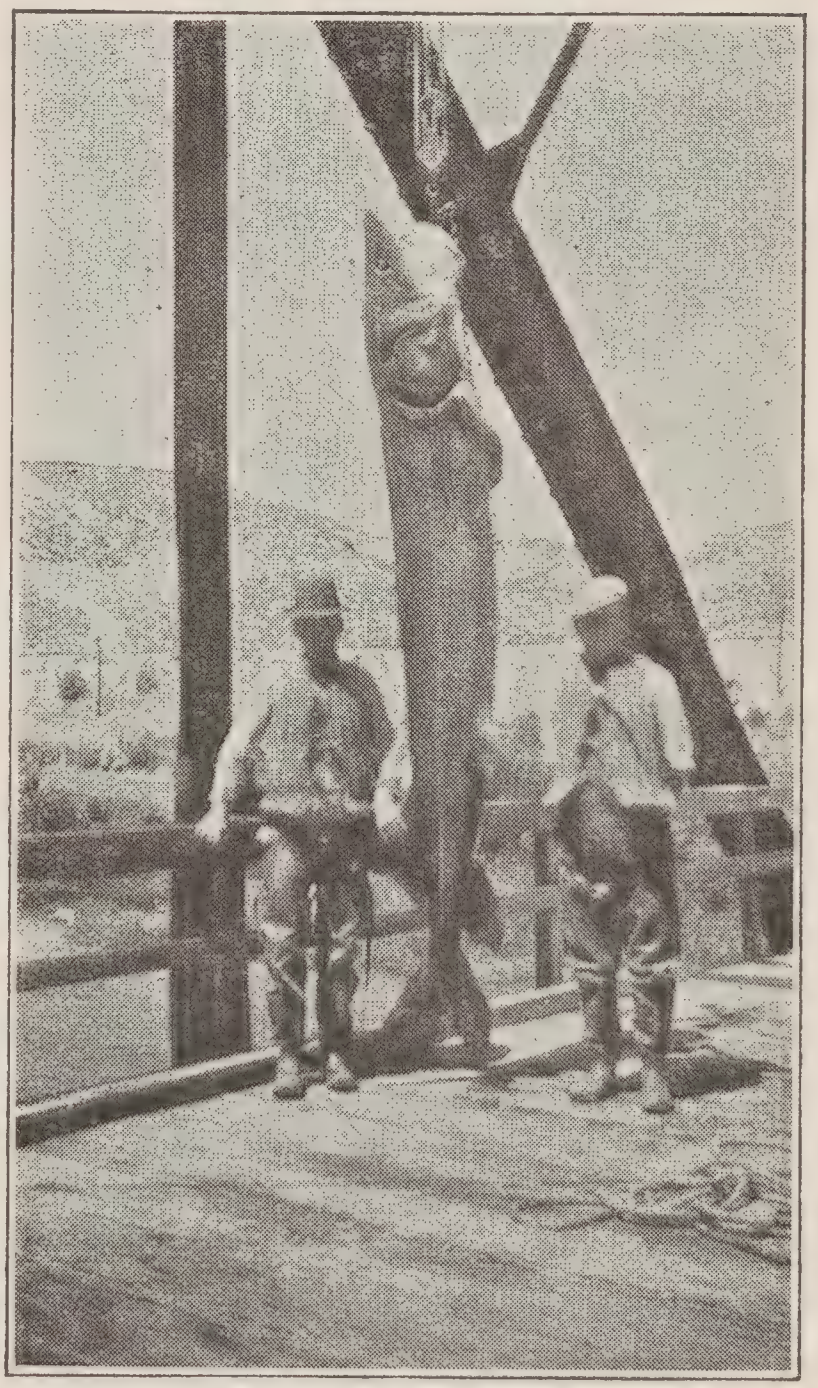
By T. B. MURRAY

District Agent, Division of Game Management, Boise, Idaho

It is reported that there are about 30 species of sturgeon. Most of the varieties ascend to fresh water from the ocean for spawning purposes. A few species spend their entire lives in fresh water. They range in size or length, it is said, from 3½ to 30 feet—personally I have yet to see a sturgeon that exceeded 12 feet in length.

The Columbia River sturgeon is one of the largest of the family. It has been taken in the Lower Snake River, having reported weight of 1000 pounds. The color is generally a dark grayish blue on the back with a lighter olive or whitish color on sides and belly. Sturgeon caught in the upper regions of the Snake River from Weiser to Lower Salmon Falls near Hagerman, grade from a bluish black on the back to a grayish green and white on the sides to a grayish white or almost clear white on the belly. (My discussion of sturgeon of the Snake River is confined to this region named.) The back and sides are covered with a series of bony plates. They have an "O" shaped bellows-like mouth admirably adapted for grasping or sucking. It can be extended as much as 8 inches below body level. The mouth is located some 4 to 20 inches posterior to the snout or nose, depending on the size of the sturgeon. Anterior to the mouth are located a set of "antennae" or feelers. These "rat tail" shaped appendages are apparently sensory organs and vary in length from ½ inch to about 5 inches depending on size of fish.

Molluscs, including snails; small, slow-moving fish, Lampreys, small insects, and plankton constitute the chief articles of diet. Sturgeon are sometimes described as a clumsy, sluggish, bottom-feeding fish. They do appear to feed principally on the bottoms of the deep holes located at various intervals in the Snake River. They have often been observed feeding near the surface on Lampreys attached to rocks



Fish caught by O. K. Rose and C. G. Atkinson near Glenns Ferry, Idaho, September, 1935.

A 490-pound sturgeon caught by O. K. Rose and C. G. Atkinson with a set line tied to the Slick bridge near Glenns Ferry, September, 1935, gave the following measurements: Length, 10 feet 3 inches; girth measurement immediately behind pectoral fins, 4 feet 7 inches; weight of head with pectoral fins attached, 92 pounds.[1] The head of practically all well proportioned sturgeon averages about 25 per cent of the total weight of the carcass. Some large male sturgeon have heads that weigh as much as 35 per cent of the total weight.

just below the surface of the water. This is most noticeable near a cataract or falls where the rocks project out of the water. When sturgeon are feeding on lampreys they come nearly to the surface, turn almost over on their backs, extend their bellows-like mouth and grasp the eel by the tail, and with two or three quick movements of the contractile mouth processes, the lamprey disappears into the gullet and on into the stomach. Having seen the sturgeon catch lampreys, you are prone to regard them as somewhat of an agile and reasonably fast moving fish.

They feed to a considerable extent on various forms of fresh-water snails. It is not uncommon to find the entire digestive tract filled to capacity with as much as 10 pounds of these small molluscs.

Snake River sturgeon fishermen always look or sound for the deepest holes. They try to find gravelly or sandy bottoms (to prevent getting lines tangled in rocks or debris) and favor such holes as have what they choose to call "penniwinkle" beds, which are in reality snail beds. It is actually possible to see sturgeon feeding on these snail beds in the deep, clear holes along the Snake River from the mouth of the Bruneau River to Lower Salmon Falls. It requires just the right combination of light, distance from water, and condition of water to make these observations possible. Sturgeons when feeding on snails appear to root with their elongated snout and suck with their bellows-shaped mouth, forcing the water back through the gill rakers. They strain out the snails and other food particles, which pass into the gullet. They appear to set themselves at an angle of about 30 to 45 degrees depending on the slope of bank or bar upon which they are feeding. This puts their extensible mouth on the same plane level as the snout. They resemble somewhat a razor-back hog when rooting and feeding, except that they can root and feed simultaneously without having to raise the head in order to feed after they have done the necessary amount of rooting.

It is contended by some that they are scavengers in that they feed to a considerable extent on dead fish and lampreys. Careful examination of stomach contents correlated with feeding habits would seem to indicate that this is true. They feed intermittently, at least they take lampreys, suckers, or squaw fish on a baited line most readily when water is slightly roily from spring run-off or from sudden storms that cause the Snake River to raise or lower perceptibly. When river is running at full flood stage, more animal matter is naturally moving along the bed of the stream and being dumped or unloaded in the deep holes. This peculiarity of the feeding habits of the sturgeon would lend weight to the argument, to some extent at least, that sturgeon are scavengers. There is no reason to believe that they cannot catch and eat alive many of the small non-game fish.

The Columbia River sturgeon can and does spend its entire life in the water of the Snake River. I have seen sturgeon less than 15 inches in length up to 490 pounds in weight taken in the areas previously named. Due to natural barriers and man-made obstructions this fish would have become extinct a long time ago in the upper regions of the Snake River, were they not able to live and reproduce entirely in fresh water. Sturgeon seem to thrive best in that segment of the Snake River where it runs through or adjacent to what appears to be ancient marine silt deposits. These finely divided clays give the water a greenish blue cast and support a profuse growth of the more useful and beneficial forms of fresh-water plants, animals, molluscs, insects and plankton. If sturgeon require an abundance of readily available food, it is always present in the stretch of the Snake River under discussion. This stretch of the Snake River probably affords better feed for all types of fresh-water life than any other section of this highly variable or diversified stream.

Very little information is available as

to the time that sturgeon spawn. Apparently they have no set time. I have seen sturgeon taken in January with what appeared to be ripe eggs. I have also seen them taken in July with eggs very close to the spawning stage. General opinion would indicate that it takes from 18 months to 2 years to produce ripe sturgeon eggs. A mature female might not spawn more than once or twice in 4 or 5 years. The spawning habit with them seems to be very erratic. Careful embryonic study might give further and definite information as to the spawning habits. It is not uncommon to take 25 pounds of ripe eggs out of a mature 250-pound sturgeon.

It is not improbable that an average of 10 to 20 thousand pounds of sturgeon are caught each year in the Snake River from Weiser to Lower Salmon Falls. This figure would seem to agree with the best information that is available from old times as well as from present day sturgeon fishermen. Sturgeon do not seem to be as numerous as they were 20 years ago.

Jordan, Everman & Clark, "Check List of Fishes," U. S. Bureau of Fisheries, p. report a white sturgeon, A. montanus, taken at Astoria weighing 1900 pounds.

Pegmatites in the Kettle Range, Washington[1]

By CHARLES D. CAMPBELL
State College of Washington

The Kettle Range comprises the north-trending mountains of Ferry County, Washington, lying between the Sanpoil-Curlew Valley on the west side, and the Columbia-Kettle Valley on the east (Plate 1). This range of mountains contains several summits of about 7000 feet elevation, and although many of the lower slopes are forested, the peaks and steep-walled canyons offer good exposure for the study of the bedrock.

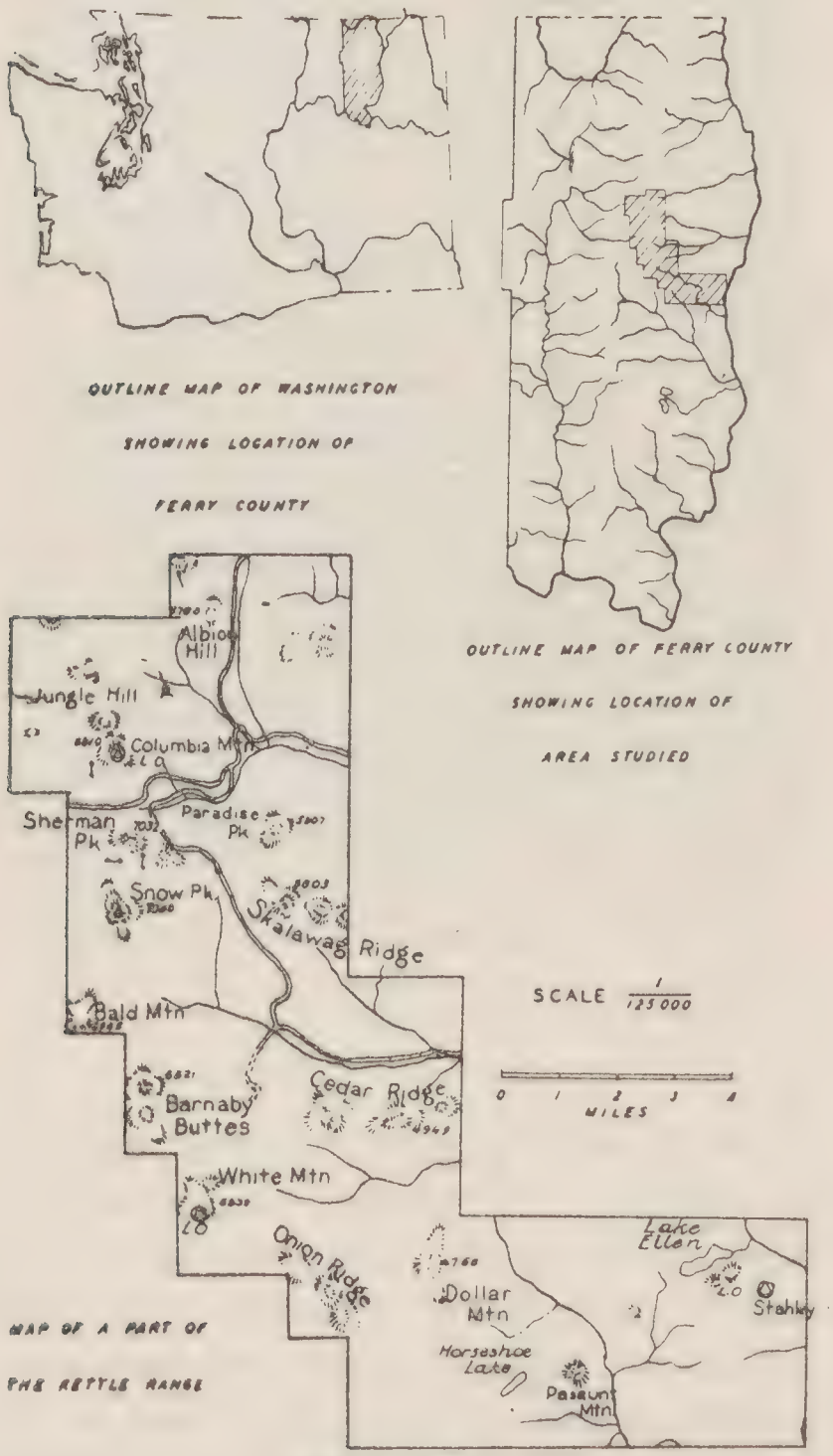


PLATE 1

The present paper contains a detail of the geological history of this range, and was carried on in connection with stratigraphic studies being done by the State Division of Geology—studies which, it is hoped, will be finished in the area along the Columbia and Kettle rivers before the completion of the Coulee high dam.

The three men who have done outstanding work in this range are Reginald Aldworth Daly, Joseph B. Umpleby, and J. T. Pardee. The first examined the north extremity of the range, in his capacity as geologist to the International Boundary Survey, in 1903, and his findings were published in Memoir 38 of the Canada Geological Survey.[2] Umpleby's work on the Republic mining area included a summary of the more general relations of the rocks of the Republic area which could be applied to the Kettle range.[3] Pardee, of the United States Geological Survey, made a careful geological and mineral examination of the Colville In-

dian Reservation which includes the south half of the Kettle Range.[4]

The general geological history demonstrated by Daly for the north end of the range[5] agrees in general with that shown by Pardee for the south half.[6] In each area, there is an older series of metamorphosed sediments and lavas, possibly correlatives of the Cache Creek series near Kamloops, B. C.; into this series a granitic to granodioritic batholith has made its way at an unknown time, possibly in the middle to late Mesozoic; finally, in early or middle Tertiary time, other intrusions rose, transecting all older rocks.

The area studied in 1935 lies adjacent to the north edge of the Colville Reservation, and the small amount of correlative work done seems to justify the use of Pardee's formation names for the rocks so close to the reservation. Thus the metamorphic rocks would be the Covada group, and the earlier intrusion the Colville batholith.

The rocks with which this paper deals are the hybrids resulting from the intrusions of the Colville batholith into the Covada group. To similar hybrid near-contact rocks in Finland, apparently the results of assimilation of one by the other, Sederholm gave the name of "migmatites."[7] The term has gradually come to be used for a considerable variety of such contact rocks, from igneous rocks thickly studded with xenoliths, or little-altered inclusions of country rock, through rocks showing various stages and types of mixing, to the nearly uniform mix rocks which are end products of assimilation.

The Covada group includes biotite and hornblende schists, quartzites, and fine-grained amphibolites, or greenstones, and a few pods of limestone. These rocks appear already to have experienced the effects of regional metamorphism before the advent of the Colville intrusion.

The northern extension of the Colville batholith in the area studied is granodiorite. The most remarkable feature of it is the extraordinary development of pegmatites. These are composed largely of quartz and feldspars, but locally contain micas, garnet, and ilmenite. So abundant are these pegmatites that in places several sills, each many score feet thick, may be separated one from another, by relatively thin septa of metamorphics. It is the pegmatite part of the Colville batholith which is most closely connected with the migmatites.

The migmatites are of several kinds. There are various injection gneisses, feldspathized quartzites and schists, swarms of xenoliths and schlieren, swirled gneisses, and darker porphyritic gneisses which are believed to be assimilation products.

(A) Injection gneiss showing parallel banding of pegmatite and schist. North side of Columbia Mountain, below sheep runway.

The injection gneisses show an interesting variety. Of widest development are intimately injected black schists. On the outcrop, the rocks show parallel wavy banding of white or pale pink pegmatite alternating with dark green or black schist layers whose biotite or hornblende crystals

parallel the banding (Plate 2A). Most of the bands are about an inch wide, but there are extremes in size from the paper-thin injection foliae on the south slope of Columbia Mountain to the bulky layers mentioned before, particularly well seen on the north side of Dollar Mountain. The more usual types can be seen best on the west end of Graves Mountain, on Cedar Ridge, and the summit of Snow Peak. At this last-named locality, the pegmatite foliae are discontinuous, and on joint surfaces which cut across them, they resemble thin wavy tongues of flame exactly like the "rain of fire" engraved by Gustave Doré as an illustration of certain editions of Dante's "Inferno."

(B) Ptygmatic folding in injection gneiss. Ten feet from A.

On Columbia Mountain, above the pass on the Kettle Falls-to-Republic road, there is a local development of exaggerated close folding of the type called "ptygmatic folding." Sections of the thin pegmatite laminae are here closely looped back and forth like the meanders of an old stream (Plate 2B).

Injection phenomena like the above are also found in quartzite layers of the Covada group. Naturally the crumpling in these resistant quartzites has not been so intense as that in the schists, but even here there is a slight waviness in the banding of them. The quartzitic injection gneisses are associated with the dark-colored ones described above, at all the places mentioned.

Injection gneisses of these kinds have been figured from many places, among which are southwest Finland,[8] the Pyrenees,[9] the south end of the Schwarzwald, close to the Rhine River,[10] and in the New Jersey highlands.[11] Within the last three years, A. L. Anderson has described injection and replacement phenomena in pre-Cambrian quartzites of Idaho resulting from the intrusion of the Cassia granodiorite.[12] So also has Carl A. Lamey for the Republic granite of northern Michigan,[13] and J. T. Stark for the pre-Cambrian granites of the Sawatch Range in Colorado.[14]

Associated with the layers of pegmatite in these injection gneisses are more massive layers of schist and quartzite through which no continuous layers of pegmatite have been passed. In them can be found abundant crystals of fresh feldspar and biotite, the latter best seen in the quartzites. Varying amounts of the feldspar were found, and in one place on Cedar Ridge, a quartzite block which had fallen away into a pegmatite sill, could be recognized only in its outlines and its content of unchanged quartzite streaks.

Another contact type of rock is the well-known one consisting of abundant inclusions of country rock in the borders of the intrusion. This type is relatively unimportant in the area studied. Where found, the xenoliths, most of them slabs of quartzite and less commonly schists, are aligned parallel to the flow structure of the host rock. It is perhaps a misuse of the term "migmatite" to include such types under it, and these are mentioned here only for the sake of completeness.

True migmatites of another kind can be

seen in the cliffs at the east base of Sherman Peak, close to the pass between it and Paradise Peak. Here is a line of 200-foot cliffs (if the talus be included), at the top of which are injection gneisses like those mentioned before. Down the cliff face, these banded gneisses are seen to fray out and become irregular; and the entire lower half of the cliffs and the talus are composed of an even-grained coarse gneiss whose banding swells and thins as it curves smoothly back and

(C) Swirled gneiss due to imperfect mixing of schist in pegmatite magma. From east base of Sherman Peak.

forth (Plate 2C). The stirring of thick taffy would produce such swirls. Throughout the gneiss, which is quite massive, the feldspar is uniform; the dark streaks differ from the light only in having a large proportion of biotite of the greenish type found in the overlying schists.

The last type of migmatite to be described, would be called simply a primary gneiss if found by itself in the field, the assumption being made that it was part of a batholith showing flow structure. However, the Kettle Range gneisses show field relations to the migmatites described above, which seem to warrant their inclusion in the same category with them. Within a short distance of the swirled gneisses of Sherman Peak, are found gneisses which are mineralogically the same as these, but which show much finer, narrower, and straighter banding. A few miles down the east slopes from here are the extensive closely-foliated gneisses which are found on the east side of the Kettle Range, from there all the way to Canada. It is the straightness and perfection of the foliation in these gneisses, together with jointing parallel to it, which controls many of the hillslopes in the lower spurs of the Kettle Range. The closely foliated gneisses are of various shades of gray, but most of them are decidedly darker than the main Colville mass near the summits of the range. They contain very few stringers of pegmatite, and have squirted a few others out into the surrounding metamorphics. The contact effects produced by the gneiss on the metasediments are negligible; the contacts themselves are sharp, and the amount of granulation in the intrusive shows how nearly solid the mass was when intruded.

CONCLUSIONS

It is believed that the contact effects produced by the Colville batholith in the area west of Kettle Falls, are due to the same conditions that Lacroix conceived for the intrusions of the eastern Pyrenees, and which Schwenkel adopted for those of the Schwarzwald. That is, the slowly advancing main mass of the Colville batholith was preceded on its journey by an ever-increasing cortège of hot mineralizing gases and vapors. These permeated the metamorphics long before the arrival of the main mass, causing the deposition of feldspar, and sufficient softening of these rocks to allow easy ingress of the advance parts of the main magma. The lit-par-lit injection of the pegmatites seems to have been more of a mechanical

process than a chemical one, such as the one which both Paige and Balk have described from the Black Hills,[15,16] and resulted in simple distension of the whole mass, with some crumpling. The migmatites of the Kettle Range are thought to be the result of mechanical mixing of the schists and quartzites in the invading Colville pegmatites, together with a lesser amount of chemical replacement. As far as the work has gone, a comparison of the ferromagnesian minerals of the gneisses and the original schists seems to support this idea; so also does the field evidence that perfection and evenness of mixing in the gneiss is greater in areas which are farther from the center line of the Colville intrusion. The thin slabs and leaves of dense mosiac quartzite and dark streaks sparsely scattered in otherwise uniform gneiss, are taken to be bits of the metamorphics not wholly broken up by the magma. Confirmation or disproof of this mechanical assimilation idea must await more detailed petrographic work this winter and field observations next summer.

[1] Presented at the Annual Meeting of the Northwest Scientific Association. December 27-28, 1935, Spokane, Wash.

[2] Daly, R. A., Geology of the North American Cordillera at the Forty-Ninth Parallel: Canada Geol. Survey. Memoir 38, 1912.

[3] Umpleby, J. B., Geology and Ore Deposits of Republic Mining District: Washington Geological Survey, Bull. 1, 1910.

[4] Pardee. J. T., Geology and Mineral Deposits of the Colville Indian Reservation, Washington: U. S. Geol. Survey, Bull. 677, 1918.

[5] Daly, R. A., op. cit.: pp. 377-382.

[6] Pardee, J. T., op. cit.: p. 42.

[7] Sederholm, J. J., Om Granit och Gneis: Comm. geol. Finlande, Bull. 23, p. 110. 1907.

[8] Sederholm, J. J., On Migmatites and Associated Pre-Cambrian Rocks of Southwestern Finland: Comm. géol. Finlande Bull. 58, 1923.

[9] Lacroix, Albert, Le granite des Pyrénées et ses phénomènes de contact: Carte géol. de France, Bull. 64, vol 10, pp. 241-304, 1898-1899.

[10] Schwenkel, Hans, Die Eruptivgneise des Schwarzwaldes und ihr Verhaltnis zum Granit: Min. pet. Mitt., neue Folge, vol. 31, pp. 139-320, 1912.

[11] U. S. Geol. Survey Geol. Atlas, Passaic Folio (no. 157), pp. 3-6, 1908.
Idem., Franklin Furnace Folio (no. 161), pp. 4-6, 1908.
Idem., Raritan Folio (no. 191), pp. 7-10, 1914.

[12] Anderson, A. L., Contact Phenomena Associated with the Cassia Batholith, Idaho: Jour. Geology, Vol. XLII., pp. 376-392, 1934.

[13] Lamey, C. A., The Intrusive Relations of the Republic Granite: idem, Vol. XLII., pp. 248-263, 1934.

[14] Stark, J. T., Migmatites of the Sawatch Range, Colorado: idem, Vol. XLIII., pp. 1-26, 1935.

[15] Paige, Sidney, The Mechanics of Intrusion of the Black Hills (S. D.) Pre-Cambrian Granite: Nat. Acad. Sci. Proc. vol. 2. pp 113-114, 1916.

[16] Balk, Robert, Inclusions and Foliation of the Harney Peak Granite, Black Hills, South Dakota: Jour. Geology, Vol. XXXIX., pp. 736-748, 1931.

St. Louis Meeting of the A. A. A. S.

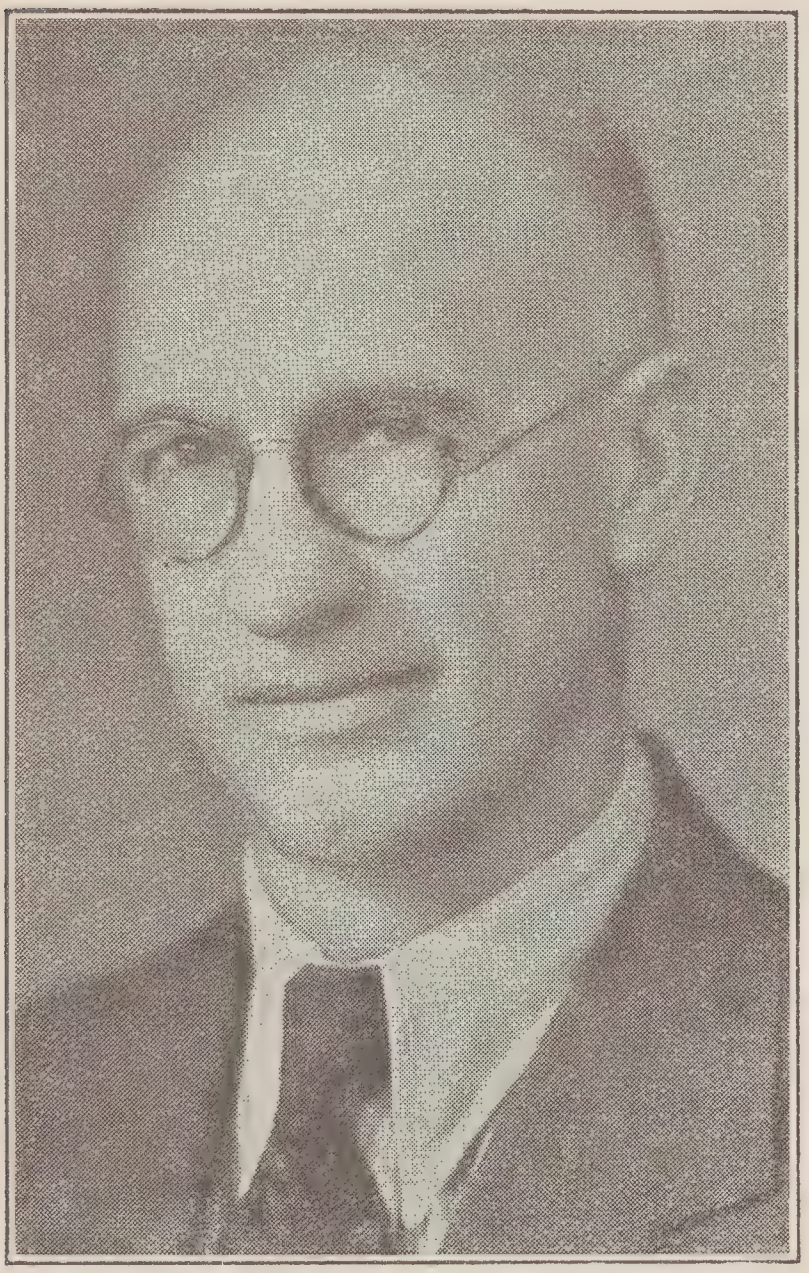
The 97th annual meeting of the American Association for the Advancement of Science was held in St. Louis December 20 to January 4. Several thousand scientists attended. Thirteen sections of the A. A. A. S. and 38 affiliated societies gave programs. The press service of teh A. A. A. S. functioned well and the St. Louis papers devoted several pages to the meeting each day.

A conference was held of the secretaries of the State Academies of Science in the Union that are affiliated with the A. A. A. S. Representatives from 30 of these organizations were present, including the Secretary of the Northwest Scientific Association. It was urged that the publications of these different organizations be exchanged in order that more widespread knowledge be had concerning research in the different sections. The same appropriation for research awards will be given to each affiliated academy for 1936 as had been given for 1935. N. W. S. A. will receive an appropriation of $50.00 from this source. When it was announced that the Northwest Scientific Association had also raised from private sources $100.00 which had been awarded for research much interest was shown and the group expressed its commendation for the interest in research shown in the Northwest.

O. W. FREEMAN.

JOSEPH WYNNE HUNGATE

Northwest Scientific Association Elects a "Native Son" (of Washington) President



J. W. HUNGATE

Joseph Wynne Hungate of the State Normal School, Cheney, Washington, elected President of the Northwest Scientific Association, at the last meeting, was born at the little town of Almota on the Snake River in southeastern Washington. His schooling began in the grade schools of the town of Pullman, the family having moved to a farm near that village. His father's threshing machine threshed wheat on what is now the campus of the State College of Washington. This institution was started there when Joe was about 12 years of age. The city of Yakima, having their choice of a State Fair or a prospective "cow college," decided that the former would be the greater asset. Enoch A. Bryan (also once a President of N. W. S. A.) left the Presidency of Vincennes University, on the banks of the Wabash, and with a little faculty and a small building established on the Palouse hills at the outskirts of Pullman an institution for agricultural and mechanical education which was to permit young Hungate to complete a college course without leaving home. This he did with the Class of 1902. He was honored with election to both Phi Beta Kappa and Phi Kappa Phi. After graduation he taught science in the high school of Walla Walla, from 1903 to 1905. He was the teacher of biological sciences in the State Normal School at Cheney from 1905 to 1918, when he was made head of the Department of Applied Sciences and Arts, which position he still occupies.

He was granted the degree of Master of Science by Cornell University in 1910. At Cornell he became member of the Sigma Xi, Honorary Scientific Society.

He was married to Winona Terpening in 1903. To them were born five sons.

Mr. Hungate has been active in the Washington National Guard, where he attained the rank of captain, and has served on the City Council of Cheney. In the Boy Scouts he worked for 20 years as scoutmaster, assistant scoutmaster and troop committeeman. In conjunction with the Spokane Council he started the first scout training course for teachers in this region. During the World War he was in charge of local War Garden work.

In scientific organizations he is a Fellow of the A. A. A. S., a member of the American Society of Mammalogists, the Cooper Ornithological Club, the Northwest Bird and Mammal Society .He was among the organizers of the Northwest Scientific Association and has rendered this organization invaluable service as Secretary-Treasurer through seven years of its early growth, from its third to its tenth year.

Mr. Hungate has also served as Member of the Council, Trustee and Vice President of the society. His wide acquaintance with the membership from his service as Secretary-Treasurer should make him well equipped for the duties of President.

Importance of Minor Elements in Plant Nutrition

By H. W. E. LARSON
Soil Extension Specialist, University of Idaho, Moscow

It was generally believed up to a few years ago that only ten elements were necessary for plant growth and of these ten only three, namely, nitrogen, phosphorus and potassium, have had to be applied as commercial fertilizers over large areas for the production of optimum crop. The elements other than the three gases and the three major elements have been termed "rare" and "minor" elements. Since many of these other elements are present in relatively large amounts in the earth's crust, I believe that the term minor elements is the better term and will be used hereafter. Also, since the importance of calcium, magnesium, iron and sulfur in plant nutrition has been quite thoroughly investigated, these elements will not be discussed. For the past fifty years and particularly the past ten years, a number of investigations pertaining to the function of these minor elements in plants and their effect on plant growth have been carried on.

The recent increased interest has been brought about by the unsatisfactory response to nitrogen, phosphorus and potash fertilizer applications to many soils both in America and other countries. Also the desire to study these elements has been given impetus by the offering of prizes by scientific and fertilizer organizations. At the 1934 annual meeting of the American Society of Agronomy, announcement was made of the acceptance by the Society of the administration of an annual award of $5,000 by the Chilean Nitrate Education Bureau for research in the importance of the rarer elements in agriculture. The March, 1935, issue of the Journal of the American Society of Agronomy contains the details of the plan for administration of the award. The Chilean Nitrate Educational Bureau has also published a bibliography containing some 1800 references on the rarer elements this last year.

The function and effect on plant growth of aluminum, antimony, arsenic, barium, beryllium, boron, bromine, calcium, chromium, chlorine, cobalt, flourine, gallium, iodine, iron, lead, lithium, magnesium, manganese, radium, rubidium, selenium, silicon, sodium, strontium, sulfur, tin, titanium, uranium, vanadium, zinc and zirconium[25] have been studied by one or more investigators. It is not improbable that some day the effect on plant growth of the entire 92 elements will have been studied.

Plants vary widely in their response to applications of minor elements, some requiring only very small applications in order to make optimum growth. Barley requires very small amounts of copper and is injured very quickly if an excess is applied, while the growth of rice will not be stunted until a much higher concentration is present.[6] The importance of one of these minor elements in plant nutrition cannot be determined by a chemical analysis of the plant. Although manganese is just as necessary for chlorophyll production in blue grass as it is in soybean leaves,[17] the average manganese content of leaves of these two plants is 30 and 160 parts per million respectively. Some plants have a higher minor element content than others because of their ability to store the excess in their woody tissues by precipitation as an insoluble compound. Certain forms of these minor elements can be used by most plants while other forms are toxic although added in extremely small amounts. Manganese sulfate is the best form of manganese to use while the bromide, chloride, sulfate, acetate and nitrate of copper can all be utilized by plants equally well.

Some of the factors which affect the degree of response obtained by rare element applications are: Soil series and classes, climate, homozygocity of seed and kind of crop. Peat and muck soils respond to copper applications better than do mineral soils. Soils derived from lava

rocks and which have an acid reaction have a high available manganese content while alkaline soils are usually low in available manganese and crops grown on alkaline soils usually respond to manganese applications. Deficiency symptoms do not show up as quickly during the spring or fall due to the short periods of daylight as they do during the long sunny days of summer.[24] A smaller application of copper sulfate to pea soils appears to benefit growth and green color development on the silt loam soils of the Palouse area[19] than is necessary on the silt loam soils in New York. The lower total rainfall of the Palouse country and the small percentage of it falling during the growing season does not permit the plant to make as luxuriant growth nor permit as much leaching of salts out of the root zone as takes place in New York. If the soil is quite dry and very little precipitation takes place during the germination and seedling period of a palnt, very small applications of minor elements may injure germination. The amount absorbed by plants will vary widely from season to season, thus causing a wide variation in content. It is a well-known fact among geneticists that selections from self-fertilized plants such as oats or wheat may sometimes vary in yielding capacity as much as 50 per cent. This difference in yielding ability of closely related plants has not been taken into consideration by many investigators in their studies. All nutrient work at the Rothamsted Station is done with pure line strains of crops.

A review of the literature pertaining to rare elements shows that very little investigation has been conducted in soil cultures or under field conditions. Some of the questions regarding any element used in palnt nutrition that are often asked are: (1) Indication of deficiency; (2) Indications of excess; (3) Plants which respond; (4) Best form and proper amount; (5) Soils usually low and which respond to applications; (6) Relation of excess in plant to excess in soil; (7) Function in plant; (8) Place of deposition in plant; (9) Normal plant and soil content.

After reviewing a large portion of the available literature pertaining to four of the minor elements; namely, boron, copper, manganese and zinc, only partial answers to the above enumerated questions have been obtained. The following information was obtained: Plants growing on soils deficient in boron die back early at the apices, and the terminal buds die or become dormant. Numerous small branches may be sent out. The leaves will be small, have numerous light chlorotic areas, and dead areas of tissue both along the margin or within the leaf. Brenchley and Warington[7] found that the roots fail to elongate properly. They become stubby. Of the 52 elements tried, none could take the place of boron. Lettuce growing on boron-deficient soils have malformed young leaves,[18] followed by a gradual destruction of the meristematic tissue. When an excess of boron is present in the nutrient medium,[10] the leaves also become somewhat yellow, proceeding from the margin toward the midveins between the lateral veins. Dark green spots are often seen around the margin of the leaf. Growth abnormalities also frequently develop especially in prunes and apricots. An enlargement of the bark below the node takes place, and the nodes themselves become enlarged in many instances.[10] Also, there is an extrusion of gum above the nodes. Plants vary widely in their response and the amount which will give maximum growth. Barley and legumes are very sensitive to boron additions[10,6] while corn will grow in the presence of larger amounts. Eaton[6] has divided plants into three groups on the basis of their boron tolerance. Culture solutions containing one in 2.5 to 5 million or boron produce the best crops. Thirty pounds of boron per acre is the usual application for general crops while 10 to 15 pounds is sufficient for truck crops such as celery on muck lands. Plants grown on high boron soils have a much higher content than those grown on soils low in boron. It stimulates the production of the vascular system[6,10]

and growth in general. It is necessary for plant growth. Nodule formation in legumes is stimulated by boron applications. It is stored in the leaf[10] and nodes of the plant. Normal citrus leaves contain 100 parts per million while leaves growing on high boron soils may contain 1000 parts per million.

The lack of sufficient copper in truck crop soils[15] causes onions to have very thin scales and poor color. Deciduous fruit trees have chlorotic leaves,[2] and the twigs die back when grown on soil deficient in copper. Barley does not produce grain[6] and lettuce leaves are abnormal in shape and color[11] in the absence of boron. An excess of copper applied to greenhouse soils caused cabbages to have a soft rot; barley leaves have a burnt appearance. The root system becomes stunted.[20] All plants respond to copper applications since it is necessary for chlorophyll production. Soluble copper salts such as the bromide, chloride, sulfate, acetate or nitrate are readily absorbed by plants. Forty to fifty pounds per acre are applied on muck soil[11] while only 5 to 10 pounds appeared to give the best results at the Idaho Station[19] on silt loam. Peat, mucks[11] and acid soils respond best to copper applications. Copper is necessary for chlorophyll production. It causes onion scales to be thick[15] and have a richer color. Copper is present in the growing parts of the plant such as the leaves, and inner bark. It is stored in tracheides, vessels and medullary-parenchyma of trees.[16] It was found in combination with plant proteids by Forbes.[13]

Manganese like copper is essential for plant growth although some plants require very small amounts. Manganese deficiency manifests itself first in the tops of plants such as tomatoes and cucumbers.[14] The web of the leaf changes from green to yellowish while the regions along the veins and mid-ribs remain green; this produces a mottled effect. Stems and leaves remain small and weak; the blossom buds turn yellow and fall off before opening. The grey speck disease of oats long prevalent in Australia[21] on non-calcareous soils high in ferruginous gravel is due to a lack of manganese. An excessive amount of manganese causes pineapples to have a stubby root system. These swellings mark the cessation of lateral growth.[26] Roots suffering from manganese toxicity have brown rings distributed at regular intervals on them.[3] Manganese nitrate, manganese phosphate and manganese sulfate are the best forms for application to low soluble manganese containing soils. Alkaline mineral soils, peats and mucks respond most frequently to manganese applications in many parts of the world.[9,23] Acid soils which are made alkaline with limestone applications often respond to manganese applications. Manganese stimulates root elongation of the seedling.[3] It appears to be essential to the oxidizing action of oxyidases and lactases.[4] Manganese is found in all parts of the plant.[5] The content in plants may vary 300 per cent due to treatment. Some data is presented in Table 1. The soil content of total manganese varies from .005 to .331 per cent, only a small portion of which may be available.

Zinc is another minor element which is necessary for plant growth. The lack of sufficient zinc caused pecan trees to have terminal branches with pronounced rosettes or very small leaves.[12] Windsor beans form pods but do not set seed.[22] The roots of trees lacking sufficient zinc do not grow abnormally.[12] An excess of zinc in the culture medium causes corrosion of the root epidermis and eventually kills the plant.[6] Some plants are very sensitive to excessive amounts, barley being the most sensitive plant. Concentrations of two hundredths to one per cent of zinc sulfate give response in water cultures. Alkaline soils, high in nitrogen such as old corrals[8] are usually low in available zinc. The application of zinc to soils corrects chlorosis of fruit trees[8] in California. It acts as a stimulant to the production of seed. The content of zinc in different plants is shown in Table 1.[17]

COPPER, IRON, MANGANESE, ZINC, NICKEL AND COBALT CONTENT OF PLANTS[1]

(Parts per million in moisture-free material)

Material	Copper	Iron	Manganese	Zinc	Nickel	Cobalt
Bluegrass	7.5	336	30	28	Trace	Trace
Soybean leaves	8.0	336	160	110	Trace	Trace
Soybean seed	12.0	70	32	18.4	3.92	
Wheat bran	16.0	210	125	75		
Wheat germs	46.0	270	150	160		
Patent flour	T	24	10	T		
Corn germs	10.0	270	40	104		
endosperm	T	30	16	T		
Rice polishings	7	168	100	70		
Polished rice	T	3	10	T		

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NORTHWEST SCIENCE SUPPLEMENT

THE CHALLENGE OF INLAND WATERS

BY

THOMAS LARGE

EAGLE CAP PEAK ACROSS MIRROR LAKE

Eagle Cap Peak (9675 feet elevation) almost in the geographical center of the Columbia drainage basin, in northeastern Oregon, is the ancient master peak of the Wallowa Mountains, from which streams of water and ice flowed outward, sculpturing the lakes and cliffs of this alpine Eagle Cap Primitive Area with its sixty lakes and hundreds of waterfalls. A stagnant relict of the ancient ice is seen high on the mountain flank at the right.

The Challenge of Inland Waters

By THOMAS LARGE

The "Retiring President's Address" at The Annual Dinner of
THE NORTHWEST SCIENTIFIC ASSOCIATION
Spokane, Washington
December 27, 1935

Salamonie River, winding among tree covered, rolling hills and fertile bottomland farms; white boles of sycamore trees seven feet in diameter and sixty feet to limbs marking the stream's course through the greenery for miles; clean water in shallows and deeps over gravel, clean sand, clay and boulders; fish a-plenty with variety for every season, and none planted by a fish commission; this is a memory of twenty years of boyhood play, swimming, boating, fishing, skating and carrying a gun for an alibi for mere wasting time out of doors. Then disaster: gas and oil found at the headwaters. Thick, black grease and a nasty smell everywhere. Fish gone. Skating ruined. No clean boulder to perch on. Salt water running in what had been fine creeks. Water unfit for stock. Waste everywhere from uncontrolled exploitation and greedy haste to "get while getting was good." A new rough population and deeds of violence. As if the smell of gas and oil everywhere were not enough to keep the disgusted populace aware of the horror which had come upon them, in the valley of the Salamonie's twin stream, the [1]Mississinewa, fifteen miles to the south, a great uncontrolled gas "gusher" roared for months like the whistle of a mighty ocean-going vessel and kept in vibration any loose window-panes or light metal in our country village, reminding us, day and night, of the curse of civilization—white man's greed which destroys ruthless of the rights of others, and, more often than not, in ignorance, the more valuable part lost too.

This boyhood memory; college and university with time chiefly employed in biological surveys of lakes and streams and ichthyological work of a state natural history survey; friendly contacts with many of [2]America's elect in Science; then more than a decade as a pioneer on an irrigated western farm, followed by a return to educational work and five seasons of private research of exploratory character on mountain streams and lakes, besides a more than passing interest in the effects of glacial ice and water in the Great Lakes and the Cordilleran areas, have kept problems of **inland waters** pretty well in focus for the speaker for well over half a century. These experiences have determined the topic on which a talk should be made on this occasion.

The shifting of Miocene drainage channels near the northern and north-eastern border of the Columbia Plateau, where basaltic mesas covering underground water in these old channels beneath the ancient "valley fills," is an interesting phenomenon, deserving, from an economic viewpoint, much more investigation than has yet been given it. Blocking of drainage, impounding of water in valleys and shifting water courses by Pleistocene ice has furnished excellent out-door sport for fifteen years past in the detective's search for evidence and clues.

Since the earliest times when tribal life was becoming fixed to places, means of preserving the purity of waters have been sought. Clear, pure water symbolizes health and the best that life has to offer. Today, on week-ends and holidays our highways are crowded with traffic pouring out of our cities, seeking some spot where there is a bit of clean water and a place to rest in the shade. It is the cleanness of snow and ice which makes the chief delight of winter sports. As populations become congested enormous sums are spent that centers of population may have pure water for drinking and other domestic uses. In early Chaldea, a pre-Mosiac decalog,[3] seeking to make easy the memorizing of moralities (which, at base, always seek the recognition of the rights of others) included, along with, "Thou shalt not remove the boundary stone" and others, "Thou shalt not pollute the stream." Riparian laws have long controlled the diversion of waters to the detriment of neighbors, until now, riparian rights are common law. Mining law and irrigation law have modified these to some extent in western America but always the first right to water is domestic use, including use of drinking water for stock. At times sinister influences have controlled courts and government agencies entrusted with the regulation of these matters. Always there are those who love "fishing in muddied waters," i. e., seeking legal dicisions in a confusion of laws which may bring economic advantage without much regard for justice.

A missionary of long experience in southeastern China is authority for the statement that in that quarter of Asia, except distilled water, no water may be had for drinking that is not polluted with human filth. Probably the same is true of India and many other areas of dense population. In such localities are found common, hideous animal parasites on the human population. [4]Dr. Robert Hegner of Johns Hopkins University is authority for the estimate that there are no less than eighty-five specific animal parasites of human beings. No small fraction of these are water born or find their "alternate

hosts" among aquatic animals. An American's first thought would probably be, that was enough of Oriental civilization.

Easily, there may be legal blind spots relating to sewage disposal. Disposal of human sewage by means of water from dwelling houses as a general practice has a short history. This is not true of the great palaces, but for ordinary people this means of disposal of dangerous wastes came into common use less than a century ago. In most cases of disposal of city wastes, as, also, quite frequently, in disposal of factory wastes, the sewage may be turned to profit under direction of sanitary research. [5]Most interesting were reports of Illinois University chemists who "fed" shredded corn stalks to an experimental sewage disposal plant and were able to generate sufficient gas to heat and light an ordinary farm home.

Our Inland Empire metropolis is not the only American city where the most desirable building sites are occupied by laundries, warehouses, "used car" lots, shanty-towns and dumps. The little item of cost of cleaning our river would open up building sites in the heart of the city for $100,000,000 investment in apartment houses, residential hotels, great retail bazaars, art galleries, studios, a variety of public buildings, and a growing university, each with open air and light and nearby view of a beautiful stream. With little of the seer, artist, or poet in their souls, many people are so tied to their ageing investments, many already far past their prime, that opportunity would have to knock with an earthquake to waken them to the present need. Everybody loves pure water and a running stream or a quiet pool adds much more to the value of real estate than the land itself. We are living in a smug little country village or at best a "mainstreet town" with a beautiful waterfall interfering with the flat spread of smugness.

And this brings up a vision of the near future (for scientific research brings quick revolution of values). Perhaps, when a half century hence, we return to visit the scenes of our mortal exploits, we shall not find our streets and sidewalks blocked by great motor bins of "hog fuel"—perhaps we shall not see our skies darkened with smoke. Perhaps sitting among us now is a young chemist who will refuse to be fodder for the great industries of the East, but instead will stay near home and work out a plan by which our "hog fuel," our saw-dust, our garbage, our weeds, will be fed to a great down-river gas plant which will also gobble up our sewage now being wasted and horribly worse. Instead of blocking traffic, fuel will return by underground gas pipes to heat with clean heat our public buildings. Children will then be playing in the pure waters of what is now "our sewer." The garrison at the fort will be swimming on warm evenings and will not be driven from their rifle range in disgust by our gas attack. Our present expensive and very conventional parks will be converted into play-grounds, places for a variety of games. What was in aboriginal days an incomparable river will be returned to the people for fishing and pleasure. Our citizens instead of taking long and dangerous drives seeking where they may briefly rest beside pure water and in shade, will, at home within our city, find waters where they may catch the limit for their creels while the family enjoys a waterside picnic. Workmen after a day of labor will stroll, or swim, or fish, and river enough for all. Summer homes will scatter from Seven-mile to Long Lake dam with ample room for yachting on unpolluted waters.

Above the city, in the valley, under which flows our subterranean water supply, farmers will be encouraged to put in septic tanks for their residences and thus protect this water supply for the city from sewage contamination which, otherwise, more dense suburban population will bring. Where community sewers are not readily reached the "septic tank" furnishes a safe and inexpensive method of rendering human wastes harmless by utilizing bacteria. Installation of a septic tank ordinarily costs less than making connection with a sewer. Where underground sand or gravel beds may be used for disposal of the outflow such disposal is highly satisfactory and the effluent rendered harmless.

Though some may think differently, there is probably no better sewage disposal arrangement for animal wastes than an irrigated field. It operates exactly on the principle of a sand filter, such as are now used by so many cities for purification of both water and sewage. While the wastes from farm animals may carry some dangerous elements, as a stream pollution they do not carry the danger of human filth. This is because of the fact that animal parasites are not ordinarily dangerous to humans. Insects and soil bacteria dispose of excrement at high speed. When this is understood it puts at rest much of the objection to trying to keep our rivers clean (based on the belief that it is impossible in an irrigated area). The irrigated farm helps instead of hinders. An occasional careless irrigater may need spanking when he lets waste water get away. Present laws provide for this. The whole danger will come from human pollution and dangerous factory or mine wastes. It is common knowledge that these may pay dividends once research is applied to them. Our paper mill wastes are used for dust control on our streets. Sugar-factory wastes return precious phosphates and potassium which the plants in their growth demand. It is not inconceivable that some mine wastes are more valuable than the ore.

In turning then to other phases of our interest in "inland waters" than its preservation from pollution, we may leave the idea that pure water is less expensive than impure

water, (a) because of the direct dividends which it may pay, (b) the indirect dividends in the safety and satisfaction of having our pleasures near our homes, (c) in health from pure water to drink, (d) in lowered cost of securing such water, (e) in the actual saving in the food value of fish which may thrive and be caught from unpolluted waters. For an appeal for population think what a talking point.

As health is of primary importance, then **purity** of water must be our prime interest. Next to this comes the interest of all in the desirable restoration of abundance of life to our waters. This is vastly more complex. In the first place a great number of influences both natural and political must be considered. So complicated is the political web of overlapping authorities that little discussion is needed. Evidence at present is that there is aroused an enlightening public opinion under the able leadership of J. N. Darling which can not be otherwise than beneficial. It is difficult to see just how public opinion may unscramble the War Department, the Reclamation Service, the Biological Survey, the Bureau of Fisheries, the vast number of overlapping state authorities set up in interest of sportsmen and commercial concerns, each disclaiming interest in the plans and purposes of the other, yet each proceeding to lay claim of sovereignity over the same waters and with total indifference to the general interest, and carrying out plans which may be totally destructive of the wealth the other should guard. When private power interests, private irrigation systems, Cary Act irrigation systems add their mite the fog certainly grows dense. In the dark days of the Civil War Abraham Lincoln called to his aid the National Academy of Sciences for solution of problems in which science might aid. As the present tangle is at base chiefly scientific it would seem that the help of the National Academy might be called to determine the facts and chart a course.

The recent announcement of the reorganization of the Science Advisory Board, the original of which (virtually a committee of the National Academy of Science) brought about the important changes in methods of weather forecasting by the U. S. Weather Bureau and the establishment of the Soil Conservation Service, indicates that scientific advice is being accepted seriously for some phases of governmental guidance. May we not hope that the whole situation of control of inland waters may come under competent review?

The problems of interrelations of all forms of life found in and related to inland waters are even more complex than the problems of politics. Vital problems of chemistry and physics; problems of turbidity in relation to light; temperature of surface and depths in relation to the oxygen supply from the surface by the semi-annual overturn of the water; questions of photosynthetic agents and primary food supply; interrelations of plankton elements involving as many in one lake as fifty species of protozoans, diatoms, algae, rotifers, entomostracans, all of which have basic relations to the food supply of carnivorous fish. Most aggravating of all is the sterilization of fine lakes which have been taken for storage reservoirs. In these lakes the entire shore waters which should furnish the major portion of the fish food are alternately covered with stored water which submerses and drowns attached shore vegetation and then with the summer lowering of water dries it out and before the melting of snows the following spring exposes it to severe freezing. Animal and plant life under these conditions suffer greatly. In Wallowa Lake the biggest organism capable of performing photosynthesis is a species of Volvox .8mm in diameter. Scarcity of vegetable food is shown by hungry suckers sometimes collecting at the outlet and gulping down floating coniferous pollen fermenting on the surface of the water. Fair abundance of diatoms and Dinobryon make up to some extent by numbers what they lack in size. It would seem that in this lake there is a gradual diminution of the fish population, chiefly suckers, introduced trout and land-locked remnants of a population of former migratory sockeye salmon for which this lake was once famous.

In some localities the work of the Soil Conservation Service is providing conditions which will restore a normal run-off of water and a higher water table will no doubt aid in furnishing a more normal habitat for aquatic plants and animals. Marshes where ducks, geese and wading birds find shallows with abundant vegetation will also be suitable for furnishing the food of fish. Beaver ponds and restored lakes will enable young fish to find safety during the growth period. Trees and shrubbery along streams besides checking erosion will keep the waters cool. Waters in which trout may thrive should never exceed 60° F.

Fish culturists get astounding percentages of hatch from trout and salmon eggs but the work of biologists in seeking or making favorable situations for planting has scarcely begun. A biological survey involves so many factors that it requires time and money. Few biologists with the broad training required of a limnologist have either time or finances to carry out projects of the magnitude demanded. From some source then must come the funds for making favorable conditions for young trout or the splendid work of the fish culturists will continue to be 95 to 99 per cent wasted. One confesses to being not a little annoyed at reading a financial report of a Fish and Game Commission involving exceedingly careful accounting for several hundred thousand dollars collected from

sportsmen with not one penny spent for biological examination of waters. It seems strange that those in charge of fish welfare do not employ competent young university men, botanists, zoologists, chemists and physicists, and for a period of a few years at least give them a chance on some depleted drainage area. It is dollars to doughnuts that they and everyone else interested will learn a vast amount that is important, and quite possibly will be able to bring about a restoration of some of the aboriginal productiveness of the streams. Protectors' salaries will be wasted if there is nothing to protect.

The challenge of industry to aquatic life of this region has at last aroused some degree of popular and scientific attention. The symposium on salmon of a year ago in our annual meeting and the wide publicity given the papers there presented through the Associated Press and several magazines indicates that the public will at least know pretty well where to place the blame for damage done. That the doers of damage have been unconscious blunderers does not excuse. It is typical of much public policy in federal and state administration to take off and try to pick a landing place from the air. The biologists of the U. S. Bureau of Fisheries are doing all they are able to insure happy landings. If we crack up and survive we may try the same thing again at first opportunity. If we are not hurt we will never think to thank those biologists. If we are hurt, be assured the same biologists will be "cussed out" roundly, though never before has an artificial lift of seventy feet been successfully operated for transportation of fish. Just why we do not put on the grill ambitious politicians who would make flying fish out of salmon is something needing explanation. A part of the blame must rest on teaching biologists who had forgotten that fish might be a resource, for even teachers of biological science have some public responsibilities which they must take seriously if public welfare is maintained.

A new, and this time, engaging challenge to the limnologist, comes with the great new lake almost rivaling in area and exceeding in depth several of the Great Lakes. One does not get the idea that the creators of this great lake are broadcasting very freely to free-lance limnologists exactly what we may expect. Accidental conversation with one person connected with the Reclamation Service gave an idea that we might hope for removal of the timber from area to be submerged. From the aesthetic side this is reassuring that we shall not have gaunt skeletons of present forests to haunt inhabitants through several generations. However, before we settle on a home-site on its shores it may be well to learn how much barren beach this lake may have.[6] Like what will be its shallows where food for fish may grow? Will there be areas where young fish may hide from the voracious elders? Will other wild-life find on its shores places of refuge? Or, will we have great seasonal variations of depth with shore vegetation eliminated? Can aquiculture make good?

Our inland waters offer a challenge and an opportunity to every scientist in whatever field. Their usefulness, their productiveness, the pleasure they can give and their purity are matters of deepest concern to all and the maintenance of these qualities at their best is a test of an individual's citizenship. To the trained engineer and scientist they are a special charge to keep.

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[1] The Salamonie and Mississinewa are two rivers tributary to the Wabash River in eastern Indiana. They lie between the great glacial moraines of that section, flowing in parallel courses in a northwesterly direction.

[2] The slightly autobiographical character of the opening paragraphs of this address makes possible acknowledgment of indebtedness to a few of the scientists who by direct instruction in class or through student discussions in laboratory and field (1891 to 1904) but more particularly by the interest in following the subsequent work and successes of personal acquaintances and friends have added to the joy of living. In approximately the chonological order making their acquaintances, they are: David Starr Jordan, Charles Henry Gilbert, Douglas H. Campbell, David Meyers Mottier, John Merle Coulter, Carl H. Eigenmann, William J. Moenkhaus, H. Walton Clark, Robert J. Aley, Arthur Lee Foley, Charles T. Knipp, Chancey Juday, William Lowe Bryan, Douglas Clay Ridgeley, J. Rollin Slonaker, John Anthony Miller, Barton Warren Everman, (Indiana) Charles A. Kofoid, Frank Smith, Stephen A. Forbes, (Illinois) Chas. B. Davenport, Henry C. Cowles, Frank R. Lillie, C. O. Whitman, R. R. Bensley, Charles C. Adams, Victor E. Shelford, (Chicago). No small part of the pleasure comes from the fact that this list includes leaders in almost every great field of scientific endeavor except geology. Acquaintance with geologists came since 1920.

[3] Time has not permitted before going to press verification of sources of these quotations.

[4] Science, Vol. , p. .

[5] Science Newsletter, Vol. , p. .

[6] An attempt at constructive suggestion is that if the level of stored water varies more than three feet in the lake, all inflowing streams be weired at their mouths to hold their waters at a constant level which should be near the maximum level of the lake, and that in addition to ordinary spillways there be fish-ways and locks for passage of boats. This would furnish areas for breeding fish-food and fish, and for rearing fish; refuges for game-birds with abundance of natural food as well as extending greatly transportation possibilities, with easy movement for all to the main body of water.

SPOKANE FALLS AT HIGH WATER

Northward from the Howard Street Bridge. An island is between the two channels here shown.

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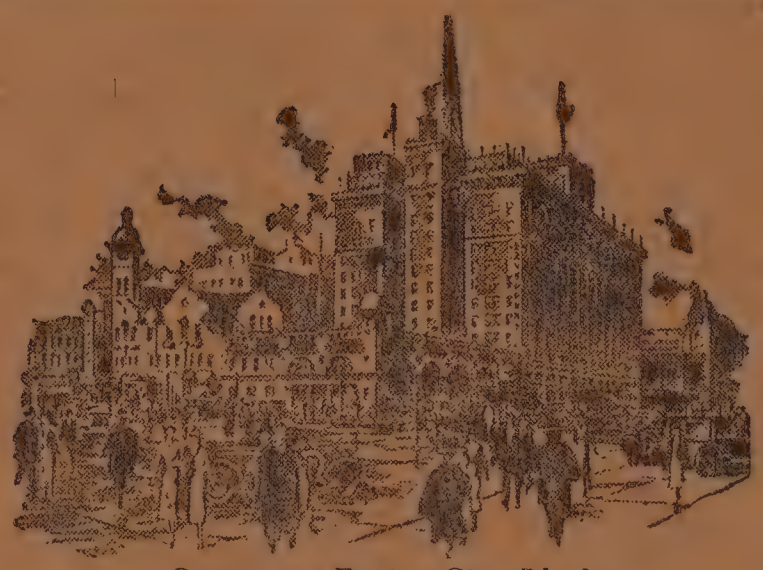

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MAY, 1936

Vol. X No. 2

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A journal devoted to the dissemination of scientific knowledge and encouragement of research in the Pacific Northwest

TO BE PUBLISHED IN FIVE NUMBERS IN 1936

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Entered as Second Class Matter, April 5, 1927, at the Postoffice at Cheney, Washington. Office of Publication, Cheney, Washington. Subscription Price to Members, Including Dues, One Dollar per Year; to Non-Members, One Dollar.
Volumes I. to IX., 1927 to 1935, Each $1.25

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NORTHWEST SCIENCE

VOL. X. MAY, 1936 NO. 2

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Montana's New President

The 43rd birthday of Montana State University on February 17, marked the inauguration of Dr. George Finlay Simmons as its seventh president. Born in Texas only a scant three years after the creation of the institution which he has been chosen to direct, President Simmons has had a career of more than ordinary interest.

As an undergraduate he spent a year in the Houston Law School, but, realizing early that scientific research held more fascination for him than law, he transferred to Rice Institute, where he studied under the noted English biologist, Julian Huxley. His college days were broken by periods of employment as a stenographer, secretary, law clerk, feature writer for the Houston Post, secretary of police of Houston, and a year and a half of service in the Red Cross Ambulance Corps, in which he rose through the ranks from private to detachment commander and adjutant. After the war he entered the University of Texas, receiving his bachelor's degree in 1921. The next year he was given an instructorship in the department of zoology at the University of Texas and completed the work for his master's degree, offering as a thesis "Birds of the Austin Region," which was later published as a book by the University of Texas.

Following a year as State Naturalist and chief executive of the Texas Game, Fish and Oyster Commission, during which time he continued his study of birds and rapidly gained recognition as an ornithologist, he was chosen as leader of a scientific expedition into the South Atlantic, sponsored by the Cleveland (Ohio) Museum of Natural History and the American Museum of Natural History of New York City.

DR. GEORGE FINLAY SIMMONS

As captain of the windjammer Blossom, President Simmons spent three adventurous years. Traced on the map of the South Atlantic, the voyage of the Blossom resembles a huge figure eight, beginning at New London, Connecticut, swinging across the Atlantic to the Cape Verde Islands and Africa, thence westward to Brazil, southward to the Roaring Forties, north to St. Helena—the island of Napoleon's exile

—and northwest to Charleston, South Carolina.

Captain Simmons returned home with a wealth of scientific material. For several years he served as curator of ornithology in the Cleveland Museum of Natural History, as lecturer in zoology at the Western Reserve University, and also as a national lecturer with the Alber and affiliated bureaus.

In 1931 he entered the University of Chicago to continue his graduate study. Here his major research was devoted to the endocrine glands, as a part of a broad program, directed by Dr. Frank R. Lillie and Dr. Carl R. Moore, which attenpted to determine the external environmental factors and the internal chemical factors regulating reproduction in the annual breeders. Dr. Simmons worked on female hormones. He was granted the doctor of philosophy degree "with distinction" in 1934. Shortly afterward he received a professorship in the department of zoology at Montana State University, and on December 9, 1935, the Montana State Board of Education appointed him to the presidency to fill the vacancy created by the death of the late Charles Horace Clapp.

President Simmons was married to Armede Victoria Hatcher in Fort Worth, Texas, in 1922. They have two sons, George Finlay, Jr., and Robert McGregor.

Bacteriology and Serology of Infectious Arthritis

From HOLLISTER-STIER LABORATORIES
Spokane, Wash., December, 1935
By D. DWIGHT MOFFITT, B. S., and RUTH MacCULLOCH, L. T.

Infectious arthritis presents a very interesting picture from a laboratory point of view. The history of previous infections, the common presence of foci of infectious nature, the occasional isolation of bacteria from the joints of chronic cases, and the complement fixation by certain strains of organisms in arthritis deformans, indicate that there is at least one type of arthritis which is infectious.

This type of arthritis is known by several names such as chronic infectious arthritis, atrophic arthritis, proliferative arthritis, arthritis deformans and the rheumatoid type of arthritis. It should be distinguished from osteoarthritis, otherwise known as non-infectious, hypertrophic, degenerative and senescent arthritis.[1]

The first symptoms of rheumatoid arthritis quite frequently follow acute attacks of "head colds" and sore throat, which again indicates the infectious nature. Rosenow[2] in a series of thirty-eight cases of arthritis deformans was able to isolate organisms from large glands excised from adjacent diseased joints. Streptococcus of the Viridans type was found in 14 cases. *Bacillus welchii* in 9 cases; Staphylococci in 3; *B. mucosis* in 1 case, and Gonococcus in 1 case. Moon and Edwards[3] in 1917 cultured non-hemolytic streptococcus from the blood in 20% of 83 cases. Clawson[4] in 1925 isolated Streptococci from the blood in a "relatively high percentage" of cases of rheumatic fever, and in 1932 reported the blood cultural studies of 50 cases of chronic arthritis in which 50% were positive for Streptococci. Forkner,[5] Shands and Posten in 1928 found Streptococci in joint tissue cultures in 15% of 63 cases. Zinsser[6] and Yu recovered an alpha Streptococcus from the myocardium and pericardium in a case of acute rheumatic fever at autopsy. Cecil,[7] Nichols and Stainsby in 1929 studied a series of 78 cases of chronic infectious arthritis and from the blood, cultured 40 "Typical Strain," 6 viridans and 2 non-hemolytic streptococci, 4 diphtheroid bacilli and 2 *Micrococcus zymogenes*

The organisms which may produce symptoms in the arthritis patient cover a wide range, which Burbank[8] groups as follows according to their frequency and intensity of reaction:

1. *Streptococci,* Various Types.
2. *Staphylococcus aureus*

3. Paracolon group of Gram Negative Bacilli.

These organisms come from such foci as: Throat, Teeth, Intestinal tract (gall bladder and appendix, etc.), Nasal Mucosa, including sinuses and antra, Genito-urinary tract (prostate, vessicle, bladder, kidney, cervix, etc.), and presented such organisms as *Streptococcus haemolyticus Streptococcus viridans, Staphylococcus aurens* and Colon bacilli.

Some authors claim that only the strains of streptococci recovered from the blood are the infectious agents in rheumatoid arthritis and because of such belief go to extreme ends to obtain such an organism from all blood cultures from arthritic patients. Various types of cultural media have been used, employing a long period of incubation which is necessary to develop these strains of streptococci. Many of the reports, of a high percentage of positive cultures from the blood, seem much too high to other investigators.

If it were possible to isolate a specific organism from all arthritic blood cultures, a specific antigen would be easy to prepare. This has been impossible with any cultural technic used up to the present time. To prepare an antigen which would be suitable for each individual case it is necessary to isolate all the organisms from all possible sources and use them as an autogenous vaccine. To this suspension is added any organisms from specific foci isolated from other cases, for which their blood shows a positive complement fixation. In this way a vaccine is obtained which contains organisms that are of a specific nature for that individual patient.

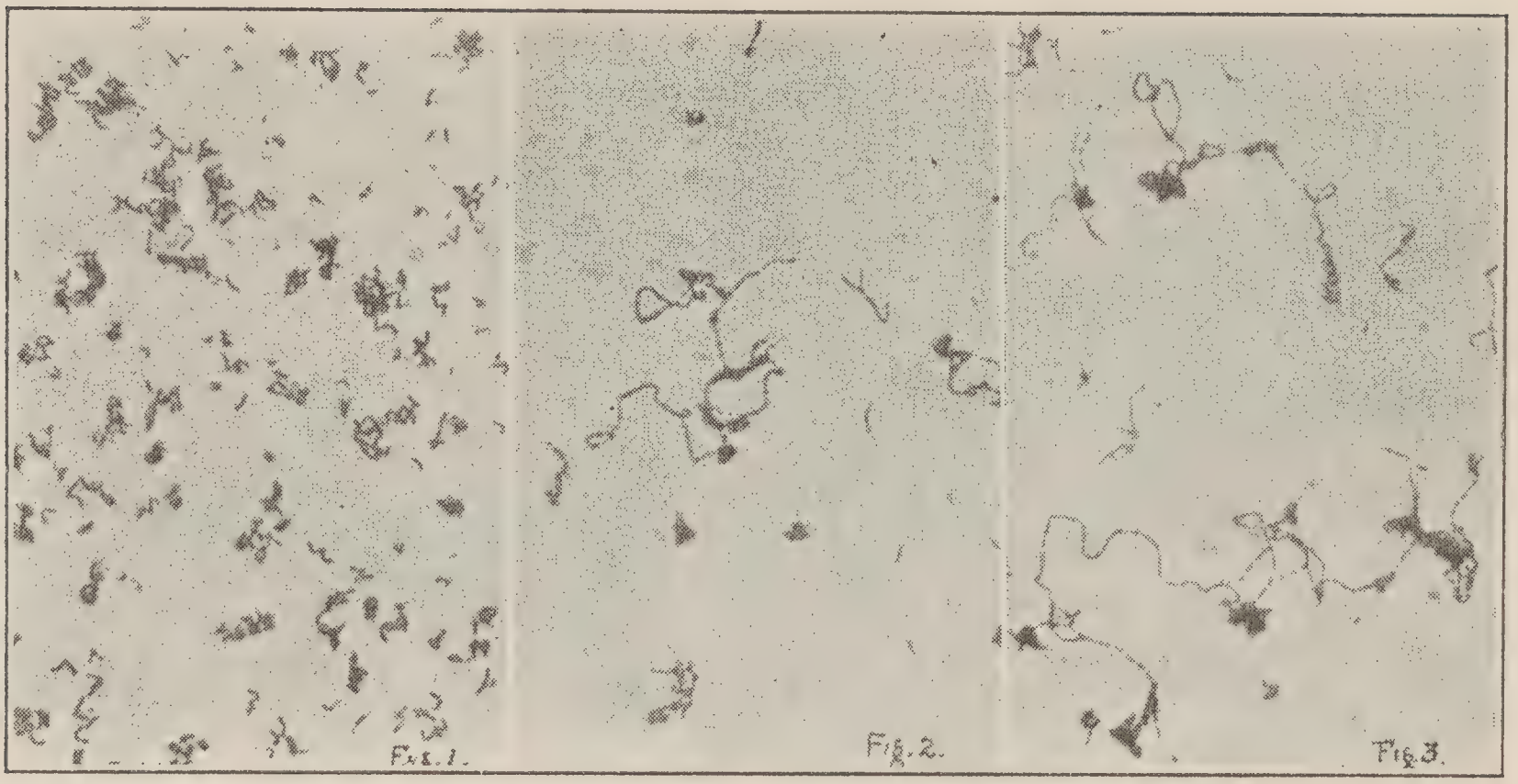
For many years the tendency of most workers has been to consider the diphtheroid bacilli obtained from human sources as contaminants or as mere saprophytes. This view in general is taken by the British Medical Research Council[9] in their summary of the literature up to 1923. In 1930 Kessel & Romanoff[10] reported a non-fatal case of generalized infection, including meningitis in which four blood cultures and the spinal fluid revealed diphtheroid bacilli. In 1934 Foord and Stone[11] report a case of endocarditis caused by a diphtheroid bacillus which is a pleomorphic streptococcus, that is, one which changed its form or morphology.

This diptheroid bacillus from the blood grows very slowly when first planted. In the routine blood cultures the diphtheroid bacillus would not have time to develop before the culture would be discarded. On blood agar plates the colonies after 24 hours of incubation are not large enough to be seen without the aid of a magnifying lens and after 48 hours when they reach their maximum growth they are about half the size of a pinhead. In order to show their presence in the blood, only the clot is used for culturing as the serum tends to prevent growth in artificial media. In the original blood culture the diphtheroid bacillus will rarely develop in less than 48 hours incubation and sometimes as long as 60 days are necessary before transplants will show positive cultures.

The peculiar fact about this organism is that after repeated sub-cultures on artificial media it loses its diphtheroid character and becomes a coccus occuring in chains.

We have seen this organism several times in the laboratory and have been able to photograph it in three stages of development. In the first microphotograph all the organisms are of the diphtheroid character. They remain in this form for several generations, not all for the same length of time. Sometimes the third generation will begin to show the coccoid forms, more often a larger number of transplants are necessary before any change is noticed.

In the second microphotograph can be seen both types of organisms, the diphtheroid and the coccoid. As soon as the coccus begins to develop their growth metamorphasis is quite rapid and usually in one or more sub-cultures the cocci will be in long chains with only an occasional diph-



theroid present.

The third microphotograph will demonstrate this cycle of their development.

The blood from 120 arthritic patients was examined and 20% of them yielded positive cultures. Of these positive cultures 71% were of the diphtheroid variety and 21% were diplococcic in character. We feel that these organisms are pleomorphic streptococci and when isolated from the blood are diphtheroid in character and that their peculiar shape may be due to their growth action on artificial media where they do not assume their chain-like characteristics in vitro as they occur in vivo. We believe there is such a thing as pleomorphism of bacterial organisms and perhaps the ones which we have classed as being found in normal individuals are in a cycle of their development where they are not pathogenic but in a few more generations may be quite harmful to their host.

From a series of 120 cases which we have cultured in the last four years it is interesting to note that they are not equally divided among the males and females. In this series the females outnumber the males almost two to one, or 65% females to 35% males.

Whether the seasons of the year have any bearing on the intensity of symptoms we do not know, but during the spring months more cases were seen than during any other three-month period. Arranging these cases by months, we find that during the month of May the largest number of cases were seen while in December the fewest were cultured.

The staphylococci are the most numerous and are followed very closely by the non-hemolytic streptococci. This leads one to believe that they are the chief factors in the production of arthritis symptoms. Associated with the staphylococci and non-hemolytic streptococci are the other organisms of the respiratory tract, hemolytic streptococci, *Micrococcus catarrhalis* and *B. friedlander* Those of the genito urinary system, Diptheroid bacilli and *B. coli.*

The complement fixation test is one way of demonstrating a correlation between patient's blood and previously isolated specific strains.

The first conclusive test in the application of complement fixation reactions in the diagnosis of infectious diseases were first made by Bordet and Gengou in 1901. In 1925 Burbank[12] made complement fixation applicable to arthritis. Since Burbank feels that arthritis is an infectious disease he has developed a technic which shows a relative specificity to different strains of bacteria.

The technic consists of using the natural complement in the patient's blood. The blood is collected and allowed to stand for 24 hours. Varying amounts of serum

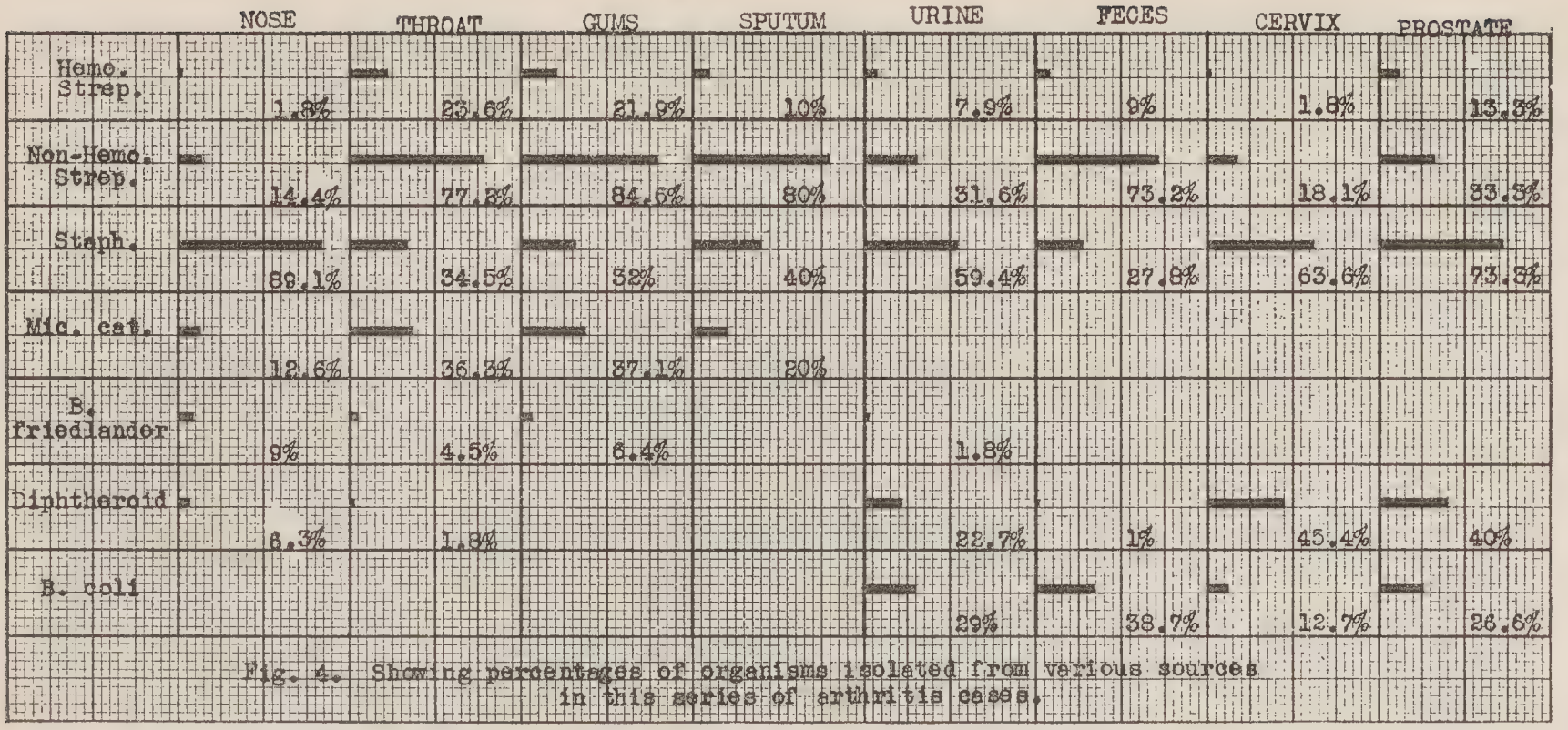


Fig. 4. Showing percentages of organisms isolated from various sources in this series of arthritis cases.

The chart (Fig. 4) represents the percentage of the various organisms isolated from the various sources in arthritic individuals. There are a few which are not shown on the chart but their percentage is so small they could not be indicated.

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ranging from 0.01 cc. to 0.1 cc. are put into tubes, 0.5 cc. sensitized sheep cells are added and the total volume made up to 1 cc. with saline. These tubes are incubated 45 minutes at 37 degrees C. and the lowest amount of serum giving a complete hemolysis is the exact unit. We have been using two units of complement and find the reactions sharper. The test proper is set up with the indicated amount of serum, with the addition of 0.5 cc. of the antigen, which is a 1% phenolized extract of specific organisms previously isolated from known arthritic individuals. The test is incubated for 45 minutes at 37° C. and then 0.5 cc. sensitized sheep cells are added, reincubated and the positive reactions noted.

Complement fixations were done in 100 cases against 105 different strains of organisms. Each case gave a positive fixation with some of these strains. They reacted to the types of organisms in the following order:

Staphylococci 28.6%
Hemolytic Streptococci 23.5%
Non-Hemolytic Streptococci 19.4%
B. coli 40.9%
Bargen Diplococci 13.6%

This percentage corresponds very nicely to the bacteriologic findings and which tends to prove that no specific strain is responsible for arthritis symptoms.

We did not find a single strain of organisms which did not react with at least three of the bloods tested. Of course it is possible that some of the positive reactions to these strains are not factors in the production of arthritic symptoms but nevertheless they must be considered and as long as these patients do react, each strain giving a positive test is included with their autogenous strains in the final vaccine.

In summarizing arthritis from the laboratory standpoint we find:

1. Certain types of arthritis are infectious in nature.

2. There is a predominance of staphylococci strains with the non-hemolytic streptococci second in importance. This is evident both culturally and serologically.

3. Twenty per cent of the blood cultures were positive. The diphtheroid form was present in 71 per cent of the total organisms found in the blood cultures.

It is not the intention of this paper to go beyond the field of bacteriology and serology in discussing arthritis. It is merely to summarize and tabulate the reports from this series of patients with arthritic symptoms, dealing primarily with the or-

ganisms isolated from the various sources and their serologic reactions.

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Experience With Administration of Cold Vaccine at St. Luke's Hospital, Spokane, Washington[1]

By MRS. JACQUELINE BAHRENBERG, Laboratory Technician

Common colds are of great economic importance because we know that among industries, colds are responsible for the workers laying off for short periods of time and it is calculated that approximately 80 per cent of the general public suffer from respiratory infections. In hospitals it is of a paramount importance that the attending personnel be free from any ailment, and common colds are the greatest inconvenience as well as the greatest hindrance to service.

What is the common cold? We have had various answers to this question. Kolmer believes that some of the aerobic organisms are responsible—probably streptococcus, staphlococcus, pneumococcus, and Micrococcus catarrhalis. He says that a local tissue immunity to these cold organisms may be possessed by the nasal mucosa and this immunity may be reduced by exposure and temperature changes or that the cold is contracted when the patient is exposed to an acutely infected case.

We have had evidence from other workers, Kurse for instance, who contends that a filterable virus can be the causative factor of common colds. There has been quite a bit of discussion regarding the prevention of the common cold and immunization by vaccines is recognized as being well worth trying.

For the most part reports of results have come from studies made in military and industrial circles because of the persons available for the testing and also the situation could be well controlled. Eyre and Lowe did some fine work vaccinating New Zealand troops and reported that respiratory infections were only 1/16 as frequent among the vaccinated as among the unvaccinated. Sir Wm. Leishman made a study of 15,000 vaccinated troops and the result was that the unprotected soldiers had respiratory diseases three and one-half times more frequently than the vaccinated ones.

Studies made in large industrial concerns by Von Solly and Park and Rappleer and Leaman show encouraging results.

We started giving cold vaccines three years ago among the employees of St. Luke's Hospital who wished the inoculation. We used a high count respiratory vaccine containing *Staphalococcus aureus Staphalbus, Streptococcus, Pneumococcus, M. catarrhalis, B. friedlander, B. influenza,* The vaccine was administered subcutane-

ously. The first year we started our dosage at 0.1, giving the vaccine every fourth day, doubling the dosage each time. We observed a number of severe local reactions and also a number of reactions similar to symptoms of a cold. When the fourth dose or 0.8cc. was reached, five out of the first eight had a tremendous reaction which was much like a severe cold with high temperature (the person feeling much as though they were coming down with the 'flu). These symptoms were gone in 24 hours.

These severe reactions in so many of our patients resulted in changing the amount of the dose. We then changed the dose schedule to start at 0.5 cc. and raised it more gradually, about 0.05 cc. at a time (with three-day intervals between doses), until a maximum dose of 0.5 cc. was reached. This was repeated one week later, then two weeks elapsed between dosages, and finally th patient came back for the same 0.5 cc. dose every month during the winter and early spring.

We found that this held 33.9 per cent with no sign of a cold. However, 20.9 per cent developed the beginning symptoms of a cold, which were terminated when they received their maximum dose of vaccine and this treatment held them free from colds for the remainder of the season. In all, 62 persons took the vaccine during 1933-34, with 54.8 per cent receiving relief from colds. Of the others, 12.9 per cent showed improvement in that they had one or two mild colds, where before they had suffered anywhere from six colds to continuous sniffles all winter. Eleven and three-tenths per cent felt they had received benefit since their colds definitely were reduced in number to only one or two colds during the year. Six and five-tenths per cent reported no benefit whatever, and no reports were available from 14.6 per cent since they finished training.

The second year, 1934-35, we gave the vaccine to 70 persons. Each patient received an initial dose of 0.05 and is was administered intradermally as compared with the subcutaneous administration of the previous year. Each patient was individually considered in respect to the increase in dose. Each dose increase depended upon the previous local or systemic reaction.

The time interval between doses, likewise, was guided by previous response. Following such a plan, the results showed that 50 per cent had no colds whatsoever. Fourteen and three-tenths per cent were absolutely controlled by a dose of vaccine when a suspicion of cold symptoms were manifest, making a total of 64.3 per cent who received relief from colds. Eleven and four-tenths per cent had one or two mild colds of short duration and 5.7 per cent persons felt that the vaccine had improved their condition in that they only had one or two severe colds. Fourteen and three-tenths per cent had moved away before reports were obtainable.

The difference in results for the second year of administration was probably due to the intradermal method of injection, over the subcutaneous method of the first year, and also that each patient was considered carefully from the standpoint of individual dosage and time interval. Receiving the proper dose at a time interval that suited the individual. Of this group there are several who had no colds at all since the first dose of vaccine in the fall of 1933. One of these persons, who has taken vaccine three years with no colds since '33, is subjected to sudden changes in temperature, in that he is a baker and goes from the steaming bakery into the huge refrigerator room dozens of times a day. He also is an ardent hunter and fisherman and glories in his present immunity to colds, whereas previously he lost anywhere from 10 days to two weeks in bed each year and had sniffly colds constantly.

We have many such among those who have had no colds since. On the other hand we also have cases like this: A student nurse had taken cold vaccine every year faithfully for four years with no colds whatsoever. This year she didn't take any

and contracted a very severe cold. She is now building up an immunity again with vaccine. She's an annual.

In 1933-34 the persons taking vaccines were 62. In 1934-35 there were 70, and this year there are 87.

It is interesting to note that of these last, 23 are taking vaccine for the third year, and 19 persons are taking it for their second year. Our patients change in personnel from year to year because many are nurses in training, or we probably would have a higher number of repeats.

	1933-34	1934-35
No relief	6.5%	4.3%
Improved, fewer colds 1 or 2 severe	11.3%	5.7%
Improved, fewer colds 1 or 2 mild	12.9%	11.4%
No colds, controlled by additional doses	20.9%	14.3%
No colds at all	33.9%	50.0%
No reports	14.6%	14.3%
Relief from colds	54.8%	64.3%
Improved (fewer colds)	24.2%	81.4%
Benefited by vaccine	79 0%	81.4%

Any cold, however, affects a person's efficiency from the industrial standpoint, but the days actually lost from work affect us economically. From July, 1932, to July, 1933, the year before vaccine was given at St. Luke's Hospital, student nurses lost 128 days from respiratory infections. From July, 1933, to December 20, 1935, practically two and one-half year of cold vaccines administration, student nurses have lost 116 days from respiratory infections. In this group 60 per cent were not immunized with the cold vaccine.

These 219 persons making up this analysis are hospital personnel, who do their full share of a day's work of eight hours plus many more. They have practically all been subjected to the same routine of living conditions, eating the same food, working the same hours one day, with overwork and its fatigue as an unavoidable consequence on another day and constantly exposed to varied infections because of their vocation.

Still, over practically a two and one-half year period, there have been but 116 days lost through respiratory infections in the training schools, as against 128 days lost in the one year immediately preceding preventive cold vaccine. And in the two years in which the vaccine has been given, approximately only 5 per cent have reported no help at all.

In summary we wish to point out that, during a period of two and one-half years, "cold vaccines" were administered to 219 hospital attaches. By individual consideration of dosage and time interval, 64.3 per cent were controlled completely by vaccine administration. In 17.1 per cent there was definite reduction in the number of respiratory infections for each person's season. Therefore, one can conclude that in 81.4 per cent a definite benefit has been obtained as a result of this vaccine administration. Only 5 per cent reported no benefit from the common cold by administration of respiratory type of vaccine.

[1] Presented before the Bacteriology and Public Health Section of Northwest Scientific Association, December 28, 1935.

Bacteriological Problems Involved in the Home Canning of Foods

By CHAS. C. PROUTY

State College of Washington, Department of Bacteriology

Because of the economic situation of the past few years the home canning of various fruits, vegetables and meats has been practised more extensively than formerly. Many families, who were content to can only the more easily processed foods such as the acid fruits, are canning in considerable quantities the non-acid vegetables and the meats.

While the bacteriological problems of

home canning have not changed they have become of greater significance because of the increased application of this method of food preservation. Often times the lack of knowledge concerning the processing operation, the use of faulty equipment and apparatus, the use of foodstuffs of inferior quality and the inability of the person in charge of the processing operation to follow specific directions have been contributing factors towards defeating the very object of the canning process, namely, that of preservation. Not only has excessive spoilage resulted but death occasionally has occurred due to the ingestion of potent bacterial toxin.

The first thing to consider when selecting the method for use in canning any food is whether or not the spores of *Clostridium botulinum* will survive the heating process, germinate and produce toxin during the storage period. Because of the danger to health this consideration is of more importance than spoilage due to other types of bacteria.

Extensive research during the past several years have shown that the germination of spores of *Cl. botulinum* are inhibited in foods having sufficient acid to lower the p.H. below 4.5 and therefore such foods may be safely processed at boiling temperature. With foods having a p.H. value above 4.5 the processing temperature must be sufficient to destroy *Cl. botulinum* spores of maximum heat resistance. This can be accomplished with safety and surety only by processing the food under steam pressure. Foods of this type are the so-called non-acid vegetables such as peas, string beans, corn, spinach, asparagus, beets, and squash and the meats. It is with foods of this nature that this discussion is concerned.

The commercial canners of foods have largely overcome the bacteriological problems of spoilage and poisoning. Spoilage in factory canned goods has been markedly reduced and since 1925 there have been no outbreaks of botulinus poisoning traced to the use of factory canned foods, while every year home canned foods are responsible for numerous outbreaks. This fact is of considerable significance when the overwhelming ratio of factory canned foods to home canned foods is considered. The commercial canner has expended considerable money, time, and effort in overcoming bacterial spoilage and poisoning. He has had to pay close attention to sanitation and to the use of scientific instruments for accurate temperature control.

Unfortunately home canning never can be expected to attain the same degree of efficiency in scientific control as is attained in the factory. The reasons for this are many. The average home maker has little or no knowledge of the interrelating biological, chemical, and physical factors involved in the canning operation. Her knowledge concerning the rate of heat conduction in various food products, the relationship between steam pressure, air pressure and temperature, resistance of bacterial spores to temperature and the growth responses of organisms to oxygen tension and temperature is vague. Yet all of these must be understood by the successful commercial canner. The home maker cannot be expected to know the details of proper methods of food processing. For this information she must rely upon advise from authoritative sources. It is here that an exceedingly weak link is found in the chain of processes involved in the canning of foods.

Tanner[1] of the University of Illinois, in recent years, made an extensive study of the information supplied by various agencies such as college extension divisions, newspapers, farm magazines and agencies marketing canning apparatus and supplies to those interested in home canning. The results of his study were astounding in that a great deal of the information made available to the home canner is not based on sound bacteriological knowledge. Of 45 agricultural extension services supplying such information only 10 gave methods acceptable from a bacteriological viewpoint. The agricultural extension serv-

ice of the State College of Washington was one of these ten.

Tanner found that many of the publications distributed by manufacturers of home canning equipment gave faulty methods and make statements far from bacteriological truths. The same was true for columns and articles published by leading farm magazines and newspapers.

The United States Department of Agriculture in 1926 through Farmers Bulletin 1471 recommended that non-acid vegetables and meats be processed only under steam pressure. Yet in 1933 many of these agencies mentioned above were recommending the processing of vegetables and meats in the water bath at boiling temperatures. Where steam pressure processing was recommended in many instances the temperature was too low and the period of exposure was too short. In other instances the recommendations were very indefinite, leaving the choice of temperature within rather wide ranges to the operator. For example, a processing pressure of 10 to 15 pounds was given by one distributor of canning equipment. In terms of temperature this represents 240° F. to 251° F., and the operator was left to choose which she should use.

Even in commercial canning where use is made of accurate recording devices and the entire process is based on sound bacteriological knowledge complete sterility of the food may not be attained. Frequently there exists in foodstuffs the spores of thermophilic bacteria considerably more resistant than the spores of *Cl. botulinum* The destruction of these spores would necessitate the application of heat to a point where the food would be decidedly overcooked and its quality greatly impaired. Thus the commercial canner prefers to use the term "commercially sterile" rather than the word "sterile" in speaking of the bacteriological condition of his product. The presence of viable organisms in canned foods is not considered of any significance if their environment is such as to inhibit growth and development.

The goal that has been attained by the commercial canner is the goal that should be reached by the home canner of foods. To accomplish this the processing must be done under pressure and accurately controlled as to temperature and period of exposure. Most pressure cookers rely on a pressure gauge alone for the control of temperature. A reliable thermometer also should be provided. The pressure gauge may become mechanically defective or the pressure recorded by it may be partially air pressure and not wholly steam pressure, in which event the temperature would fall short of that desired.

Granting that the thermometer can be accurately controlled, the period of exposure must next be properly adjusted. This is based upon the conductivity of heat in the food being processed and upon the quantity or size of the container. For example, corn conducts heat less readily than beans or peas and therefore requires a longer period of processing.

Granting that the processing as to temperature and period of exposure are properly carried out, subsequent bacteriological changes may result due to the entrance of organisms through defective seams. And, finally, canned foods should be stored at relatively low temperatures to prevent the growth of thermophilic organisms that have survived the canning operation.

Until home canning operations reach the degree of temperature and period of exposure to temperature control as is maintained in commercial canning, all home canned non-acid vegetables, non-acid fruits, and meat products should be subjected to boiling temperatures prior to tasting and serving. Such treatment will destroy any botulimus toxin that may be present, thereby giving protection against this highly fatal disease.

REFERENCE

[1] Tanner, F. W. Home Canning and Public Health. American Journal of Public Health. Vol. 25, No. 3, p. 301, March 1935.

The Study of Surface Forces Between Solids in Contact[1]

By G. W. HAMMAR and CHARLES DOUGLAS
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When solid surfaces are brought in contact they exert on each other, in addition to the gravitational force, forces which vary with the temperature.

The purpose of the study is to find the strength of these surface forces at various temperatures and to find out whether or not they vary with the time of contact. No record of previous work on this subject has been found.

The apparatus consists of two polished brass surfaces, one of which is so suspended that it may be brought into contact with the other under such conditions that the force required to break the contact may be measured. This is accompiished by having the movable surface fastened to one of the horizontal arms of a light frame of wire shaped like an inverted T. The vertical stem of the frame carries a light galvanometer mirror and is suspended by means of a fine glass fiber from a torsion head. A solid brass boss soldered rigidly to the bottom of the apparatus furnishes the second surface. The swinging system carrying the movable surface which is spherically convex may be rotated so as to bring the two test surfaces into contact. The torsion necessary to separate them again may then be evaluated by observing the rotation of the torsion head.

The apparatus is enclosed in a brass tube with a glass window in front of the mirror and the brass tube dips for the lower one-fourth of its length into an oil bath, the temperature of which can be raised by means of an electric heater. The rest of the brass tube is thermally insulated with cotton padding except for the window in front of the mirror.

By varying the temperature of the surfaces and the length of the interval during which they are in contact and measuring the torsion necessary to break the contact, it is expected that some of the properties of the adhesive forces can be determined and an explanation of their behavior be given.

The larger contact surface is a polished plane of commercial brass, 2.1 cm. by 1.5 cm., firmly soldered to the bottom plug of the brass tube and is, therefore, in excellent thermal contact with the oil bath. The smaller surface is a section cut from a sphere of .58 cm. radius. This shape was chosen because it would be difficult to keep two plane surfaces parallel while they were being brought into contact and separated. The spherical surface is soldered to the end of one of the horizontal arms of a light wire frame in the form of an inverted T. The center of the surface is 1.75 cm. from the vertical axis of the frame. The other horizontal arm carries a counter weight. The vertical stem of the frame carries a small galvanometer mirror and is suspended by a fine fiber drawn from common glass. The constant of the present fiber is .861 dynes cm./radian at 26°C. and .863 dynes cm./radian at 60°C. As a principal axis of the suspended frame lies along the suspended fiber and as the fiber is supported in the center of rotation of a torsion head, the only forces transmitted to the suspended frame are the constant supporting force and the torque.

The torsion head is turned by means of a light string running over a pulley fastened rigidly to the torsion head. This makes it possible to turn the torsion head very slowly and steadily and with minimum disturbance to the suspended system.

To eliminate the effects of moisture films on the contact surfaces a calcium chloride drying tube is connected at the upper and lower ends of the main tube.

The system is very sensitive to jars and vibrations. To minimize the effects of these mechanical disturbances the system rests on a base which is supported by sawdust held in a large box. The support

is firm enough to hold the system in alignment and at the same time eliminates most of the vibrations due to outside causes.

The system was held at a temperature of 110°C. for eight hours and then was allowed to cool before any measurements were taken.

The experimental procedure is as follows: The temperature of the oil bath is brought up to the desired value and held there for an hour or more until steady conditions have been attained. It is assumed that the temperature of the contact surfaces is then equal to the temperature of the oil bath. This is justified by the good thermal contact between the fixed brass surface and the outside oil bath and by the fact that no readings have been recorded at temperatures above 80°C. The two test surfaces are then brought into contact and left thus until the spherical surface has reached the temperature of the larger surface. The surfaces are then separated by turning the torsion head so slowly that the movable system does not swing about the point of contact. When the torque becomes large enough to separate the two surfaces the suspended system swings free. It will come to rest in a position in which there is no twist in the fiber. The angle through which the suspended system has moved will then be the angle through which the torsion head has turned from the position which brings the surface just into contact. This angle is measured by means of a scale image reflected from the mirror on the suspended systems and observed in a telescope.

The following results have been obtained:

1. The surface attraction increases exponentially with the temperature over the range investigated, which runs from 285°K. to 347°K., in which temperature range the force goes up from $2X10^{-3}$ dynes to 185 $X10^{-3}$ dynes. These numerical values depend on the particular surfaces used.

2. When the surfaces are brought in contact at one temperature and then cooled down to a lower temperature while still in contact, the force required to separate them is characteristic of the higher temperature at which they were in contact rather than the lower temperature at which the break occurred.

3 The surfaces do not separate under the influence of a force smaller than a limiting one characteristic of the highest temperature at which the surfaces are in contact, no matter how long this force acts. This shows that the contact forces are not of a viscosity type.

It is intended to extend this investigation to other surfaces than brass and to a much wider temperature range.

The apparatus was planned and built by the senior author, and experimental results were obtained by the junior author.

[1] Presented to the Chemistry-Physics Section of Northwest Scientific Association, Spokane, Washington, December 27-28, 1935.

Molecular Rotation in Crystalline Solids[1]

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Years of study and experimentation with gases have led us to a kinetic picture of them in which the molecules are in ceaseless rapid motion in random directions. The molecular "population" of all gases is so great that, except at very low pressures, frequent collisions occur in the course of this motion. As a result in the case of polyatomic molecules many are set to spinning or rotating. It is very easy to picture how such motion could be imparted during the collision, for example, of two dumbbell-shaped diatomic molecules. The results of band spectroscopy and the application of the theory of equipartition of energy to specific heats substantiate

the correctness of these ideas.

Passing now to the liquid state brings us to a condition of matter concerning whose nature we know relatively little. We do know of course that while the molecules of a liquid no longer possess the great freedom of motion characteristic of the gaseous state, nevertheless the freedom must be considerable. Hence the suggestions which have been made that molecules in liquids may be rotating under various conditions are readily accepted with little hesitation.

The suggestion that molecular rotation might occur in hard, rigid, crystalline solids, is a concept which many might feel some hesitancy in accepting. There is, however, a rapidly increasing mass of data in support of such an idea.[2] By molecular rotation is meant a continuous spin or rotation of molecules, ions, or atom groups in the crystal about one or more axes or a point. Such motion we believe is possible only in the case of certain crystalline substances and in these only above certain definite minimum temperatures which, however, in the case of many solids showing rotation are below room temperature.

Pauling[3] and, subsequently, other have attacked this problem from the theoretical standpoint using the new quantum mechanics. For our purpose it will suffice to consider the picture of molecular motion in a crystal which we would form on the basis of classical mechanics, which, however, is not essentially changed by the introduction of the quantum mechanics. The forces between the atoms in a molecule are probably much stronger than those between atoms in different molecules. Hence as a first approximation the crystal may be considered to be a collection of rigid molecules held in a regular arrangement by rather weak intermolecular forces. Due to thermal motion a molecule will describe small movements about its equilibrium orientation for which its potential energy is a minimum. Now if the potential energy of the molecule in the vicinity of the equilibrium position is small compared to that for other positions, the difference being much larger than kT, the average molecule at temperature T will carry out small vibrations or oscillations about its equilibrium position. If the total variation in potential energy is smaller than kT, the kinetic energy of the average molecule will carry it into any orientation, so that it will undergo rotational motion. Hence certain crystalline solids at some temperature below their melting point may be expected to show a transition from oscillation to rotation of the molecules in their lattices.

What crystalline solids may be expected to show molecular rotation? Pauling's study indicated that those molecules or atom groups which possess a small moment of inertia may show such motion. This condition will be fulfilled chiefly by atom groups containing one heavy atom and one or more light atoms, as for example, CH_4, NH_3, H_2O, CH_3 groups, and NH_4^+ ions. However, certain long chain hydrocarbon radicals about the chain axis, CO_3^{--} ions, NO_3^- ions, CN^- ions, O_2 and N_2 molecules in solid oxygen and nitrogen, and others also meet the condition and are found to rotate. Thus ammonium salts should show rotation of the NH_4^+ ion, hydrates of the water molecules, ammoniates of the ammonia molecules, carbonates of the CO_3^{--} ion, nitrates of the NO_3^- ion, and cyanides of the CN^- ion. Also the solid halogen halides, solid hydrogen sulfide, nitrogen, oxygen, hydrogen, methane, silicane, and others should show rotating molecules.

We now have experimental evidence for such motion in practically all of the above mentioned cases. The evidence is supplied by at least three distinctly different fields of study: thermal measurements, crystal structure analysis by means of X-rays, and dielectric constant determinations. In Table I a portion of the data on molecular rotation in solids is listed.

It seemed to us that such an unusual phenomenon deserved a systematic investigation, since most of the results up to the present have come as incidental findings

Solid	Temperature at which rotation sets in	Rotating group	Source of data
H_2	<11.°K	H_2	C. S.*
CH_4	20.4	CH_4	T. D. and C. S.
N_2	35.4	N_2	T. D. and C. S.
O_2	43.8	O_2	T. D. and C. S.
HCl	98.	HCl	T. D. and C. S.
H_2S	103.5	H_2S	D. C.
Ice	203-243	H_2O	T. D.
NH_4Cl	242.7	NH_4^+	T. D.
NH_4Br	235.1	NH_4^+	T. D.
NH_4I	230.6	NH_4^+	T. D.
n-$NH_3(C_5H_{11})Cl$	242.	C_5H_{11}	C. S. and T. D.
$NaNO_3$	548.	NO_3^-	T. D.
NaCN	284-289	CN^-	T. D.
$Ni(NH_3)_6Cl_2$	<298	NH_3	C. S.
$Al_2(SO_4)_3 \cdot K_2SO_4 \cdot 24H_2O$	<298	H_2O	C. S.

*C. S. = Crystal Structure; D. C. = Dielectric Constant; T. D. = Thermal Data.

DATA ON MOLECULAR ROTATION IN CRYSTALLINE SOLIDS

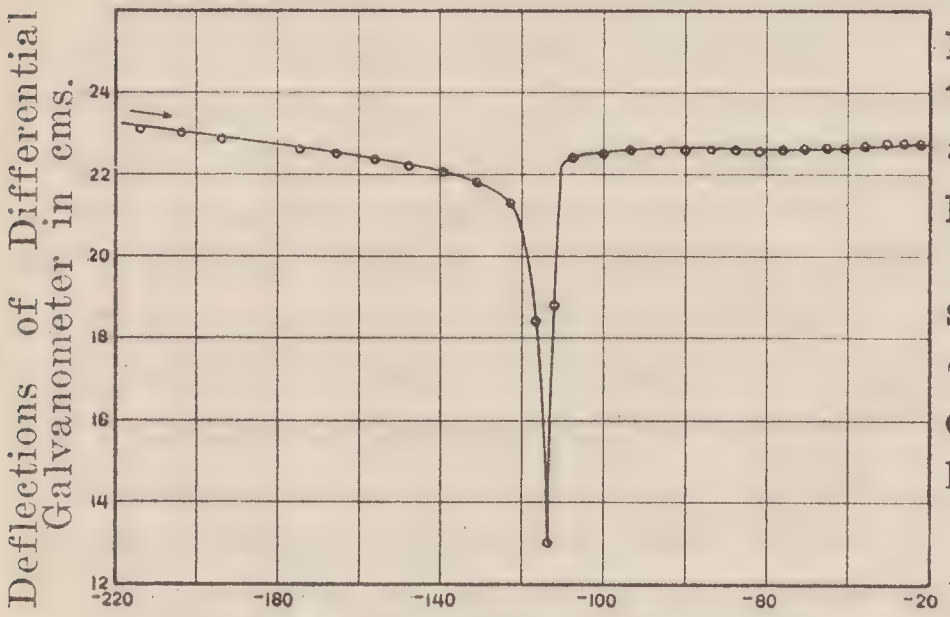
of studies made primarily with another objective in view. We have, therefore, undertaken and have underway in this laboratory systematic studies of ammonium salts and of hydrates for the purpose of locating the transition points where rotation sets in. The method used is a thermal one.

It takes energy to set these minute groups spinning, just as it takes energy (enormously more of course) to set a flywheel or motor armature to rotating. Hence at the point where rotation sets in a definite amount of energy must be absorbed. Heat capacity measurements would, therefore, be ideal for this type of study. Lacking the equipment for such measurements we are instead studying the heating and cooling curves of the solids by a differential thermocouple method which involves comparison of the sample with a neutral body known to show no transitions in the temperature range being investigated.

The neutral body, sodium chloride usually, and the sample being studied are placed directly in separate wells in a gold-plated copper block which is placed in a thin-walled glass tube in a mechanically stirred temperature bath. Heating and cooling devices for the bath are provided so that the temperature can be caused to rise or fall at a desired uniform rate over the temperature range. One junction of a differential copper-constantan thermocouple is placed in the neutral body and the other junction in the sample. A temperature thermocouple of copper-constantan is also placed in the sample to indicate its temperature. The differential thermocouple is connected directly to a sensitive galvanometer, differences in temperature of the two junctions being read as a deflection on a scale at a distance of one-half meter. The e.m.f. of the temperature thermocouple is read to micro-volts with a Leeds and Northrup type K potentiometer.

The procedure, for example, in the case of an ammonium salt is to cool the sample and neutral body in the temperature bath to the sublimation point of solid CO_2, -78.5°C, thus freezing out the motion. The bath is then started warming up at the uniform rate of say, one degree per

minute. Readings of the temperature thermocouple and differential thermocouple are taken at one minute intervals over the temperature range being studied. The differential thermocouple gives a constant reading as long as the two junctions are at the same temperature or as long as they maintain the same temperature difference. At the transition point where rotation sets in, the sample will momentarily cease warming up while the rotational energy is absorbed. This results in a difference in temperature of the two junctions and a change from the constant reading of the galvanometer. Plotting galvanometer deflections against time, or e.m.f. of the temperature thermocouple, we have at this point a more or less shape break in the curve with the presence of a maximum flections against e.m.f. the temperature at or a minimum. In case we have plotted dewhich the transition occurred can immediately be determined by reference to the thermocouple calibration curve. The curve for ammonium chloride, Fig. 1, is a typical result of one of these studies, and was made as a preliminary determination with a less refined apparatus for the purpose of checking the method. The minimum on the curve is at -30.5°C, which is in satisfactory agreement with the value -30.4°C from specific heat measurements.



Thermocouple.
FIGURE 1.
WARMING CURVE OF AMMONIUM CHLORIDE FROM -60° to -8° C.

These rotational transitions as a rule are readily distinguished from so-called polymorphic transitions which are inversions from one crystalline modification to another. Polymorphic transitions are characterized by:

1. More or less great change in the crystal lattice.
2. Each modification has well-defined physical properties which alter discontinuously with the transition.
3. They frequently show the phenomenon of hysteresis.

In the rotational transitions the specific heat curve may show a maximum at some point instead of a real discontinuity, and the crystal lattice and physical properties alter gradually in passing through the point.

No data are yet available from our studies of ammonium salts, but a study of copper sulfate pentahydrate has been completed and will be submitted for publication soon.

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The Origin of Fatuoid Oats With Particular Reference to a Hybridization Theory[1]

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INTRODUCTION

Fatuoids, or false wild oats, are aberrant grain-types which occur sporadically in cultivated oats. Oat plants bearing fatuoids are, in general appearance of plant characters, apparently identical with the variety in which they occur; in other words, fatuoid plants differ from the normal only in certain characters of the grain. Fatuoids may occur in either a homo-

zygous or a heterozygous state.

The homozygous fatuoid differs from the cultivated plant in three main characters of the grain, namely, in articulation, pubescence, and awn development. A large, horseshoe-shaped "sucker-mouth" articulation is present on all grains of the spikelet; dense, bushy pubescence is present on both callus and rachilla; and a strong, twisted, geniculate awn is present on each grain of the spikelet.

The heterozygous fatuoid is, with respect to the grain chcaracters mentioned, intermediate between the homozygous form and the cultivated variety in question. It segregates, approximately, in the ratio of 1 homozygous fatuoid : 2 heterozygous fatuoids : 1 normal cultivated type; all segregates being, apparently, of equal vigor.

The origin of fatuoids has been the subject of considerable controversy for nearly 50 years, and remains still an unsettled problem. Involved in the solution of this problem are implications of both scientific and economic importance. Accurate knowledge of the mode of origin might reasonably be expected to elucidate, to some extent, the general problem of variation; and it would in all probability point the way to methods for the eradication or control of the fatuoid, which is in many districts very troublesome in plots or fields of high grade seed oats.

REVIEW OF LITERATURE

Early Literature

The earliest report of a direct study on the origin of fatuoids is that of Haussknecht, published in 1884 and cited by Zade (17). Haussknecht observed, in Thuringia, a continuous series of forms between *Avena sativa* and *A. fatua* which he called *A. fatus var. transiens* or "Zwischenformen." He believed, in accord with the general belief of that time, that these forms could not have arisen from interspecific hybridization as no diminution of fertility was observed.[3]

Koernicke and Werner, in a paper published in 1885, reviewed by Stanton, Coffman and Wiebe (14), reported studies on intermediate forms similar to those studied by Haussknecht which, they concluded, originated through natural interspecific hybridization. This direct contradiction of Haussknecht's conclusion marks the beginning of the controversy regarding the origin of fatuoids.

In 1900 Fischer (14) reported extensive investigations on intermediate forms. He found that these types did not possess the property of dealyed germination as did *A. fatua* He observed that intermediate forms appear "spontaneously and quickly among the weakly haired and awned, gray-kernelled winter oat," and seriously questioned their origin through natural crossing.

In the reports of Nilsson-Ehle published in 1907 and in 1911 (14) these intermediate forms were referred to for the first time as "fatuoids." The theory was advanced that the fatuoid probably originated through a loss-mutation in cultivated oats.

During the period from 1907 to 1914 Criddle (14) published several papers on "white wild oats" or "false wild oats." He gave valuable information on the characteristics of fatuoids and concluded that they originated by mutation.

Zade, according to Stanton, Coffman and Wiebe (14), reported in 1912 the results of experiments with "Zwischenformen" and stated that these types originated by natural crossing between *A. fatua* and *A. sativa*. In 1914 Tschermak (14) came to the same conclusion after similar experiments.

This brief review of the earlier work is probably sufficient to recall the historical development of some of the present viewpoints. For more complete reviews, the reader is referred to Stanton, Coffman and Wiebe (14), and to Huskins and Fryer (4). In order to present more comprehensively the different hypotheses which have been advanced with reference to the origin of fatuoids, the more recent contributions will be reviewed in relation to the particu-

lar hypothesis to which each author subscribes.

MUTATION HYPOTHESIS. As stated by Nilsson-Ehle (11) in 1921, the mutation hypothesis assumes that there occurs in one of the gametes a mutation affecting the gene complex which governs the characters of the fatuoid complex. Such an abnormal gamete, mating with a normal gamete, gives rise to a heterozygous fatuoid plant. This plant when selfed produces normal, heterozygous fatuoid, and homozygous fatuoid plants in the ratio of 1:2:1, respectively.

Jones (10) has recently (1930) advanced a modified mutation hypothesis based on Huskin's (7) $\frac{ABC}{ABC}$ formula for normal *A. sativa*. (See chromosome aberration hypothesis below). This hypothesis assumes that chromosome B carries the factors for *fatua* grain characters, and that chromosome C carries factors for *sativa* grain characters; the factors on C being epistatic to those on B. Mutation in C removes this epistasis, and thereby allows factors in B to express *fatua*-like grain characters.

Nishiyama (12) concluded in 1931, after extensive genetic and cytological observations, that the common fatuoid, with the normal chromosome number, originates by mutation in the C chromosome; and that fatuoids which show deviations from the normal chromosome number (i. e. Huskins' (7) B- and C-series, Goulden's (3) families II. and III., and Nishiyama's (12) strains H_{20}-35 and H_{58}-12) originate through chromosome aberrations. More recent studies by Nishiyama (13) have confirmed his earlier viewpoint and that of Jones (10).

POTHESIS. The chromosome aberration hypothesis, stated by Huskins (5, 6, 7) as an explanation of the origin of fatuoids, is based upon Winge's (16) explanation of the origin of speltoids in wheat, and like the latter involves a consideration of the phylogeny of the species concerned. The higher species of *Avena* and *Triticum* are believed to have evolved by multiplication of the chromosomes of more primitive species. In *Avena* the hexaploid species *A. sativa* which contains most of our common cultivated varieties, has 21 pairs of chromosomes representing three sets of each of the seven chromosome pairs of the diploid species. The set, or di-triploid group, of chromosomes concerned with grain characters is represented in *A. sativa* by the formula $\frac{ABC}{ABC}$. The $\frac{B}{B}$ pair differs from the $\frac{C}{C}$ pair only in the factor or factors affecting articulation, pubescence, and awn development of the grain. $\frac{B}{B}$ carries factors which determine fatuoid grain characters; $\frac{C}{C}$ carries factors which determine normal grain characters; and $\frac{C}{C}$ is epistatic to $\frac{B}{B}$. Normal pairing of A with A, B with B, and C with C will maintain the equilibrium of the groups an dtrue-breeding progeny will be produced. But, if faulty pairing takes place occasionally between B and C, gametes of the types ABB and ACC will result. The mating of ABB with the normal ABC gamete gives an $\frac{ABC}{ABB}$ zygote. It is assumed that this zygote, having an extra "dose" of fatuoid factors, develops into a heterozygous fatuoid. The resulting individual, when selfed, will segregate for normal $\frac{ABC}{ABC}$, heterozygous fatuoid $\frac{ABC}{ABB}$ and homozygous fatuoid $\frac{ABB}{ABB}$ types in the ratio of 1:2:1, respectively.

[1] Presented at the annual meeting of the Northwest Scientific Association December 28-29, 1934. This paper summarizes and simplifies a previous article by Aamodt, Johnson and Manson (1).

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[3] Evidently Haussknecht believed, as did many botanists of his day, that sterility was the criterion of interspecific hybridity. The objection to the acceptance of intermediate forms because of the lack of sterility would not be valid at the present time, since it is generally accepted that hybrids between species are not necessarily sterile.

Huskins (7) describes three types of fatuoids: In A series the heterozygous type has 42 chromosomes and segregates in the ratio of 1:2:1 for normals, heterozygous fatuoids and homozygous fatuoids, all segregates being of normal 42-chromosome complement; in B series the heterozygote segregates for normals, heterozygotes and fatuoids having 42, 41, and 40 chromosomes, respectively; in C series the heterozygote segregates for normals, heterozygotes and fatuoids having 42, 43, and 44 chromosomes, respectively.

For more complete reviews of the recent literature bearing directly on the various hypotheses, the reader is referred to Jones (10) and Nishiyama (12).

NATURAL HYBRIDIZATION HYPOTHESIS. In his book, "Der Hafer," published in 1918, Zade (17) discussed his investigations with fatuoids. He stated that grain types, intermediate between *A. fatua* and *A. sativa* are frequently found in samples of threshed oats; and, that the progeny of these intermediates segregated for *sativa*, intermediate, and *fatua* types in the ratio of 1:2:1. Zade believed that these types arose as segregates from a natural cross *A. fatua* and *A. sativa.* The segregation from this cross, however, was not of the monohybrid type such as was observed when the intermediates were tested. To explain this difference in breeding behavior Zade assumed that the intermediate forms, heterozygous for one factor, were segregates from a cross which had occurred several years previously. Thus, the generations from the intermediates were not F_2, F_3, etc., but F_{x+2}, F_{x+3}, etc., Zade believed that further evidence in favor of the natural crossing hypothesis was provided by the fact that intermediate types were of frequent occurrence, while mutations are known to occur very rarely.

Challenged by the conclusions of Nilsson-Ehle, Zade refused to accept the former's statement that wild oats do not occur in the vicinity of Svalof, Sweden (a fact submitted by Nilsson-Ehle as conclusive proof against the natural crossing hypothesis). Zade also pointed out that Nilsson-Ehle's seed stocks were not necessarily pure lines.

In 1929 Tschermak (15) published data from the study of several crosses between *A. sativa* and *A. fatua* which he believed strongly favored the natural hybridization hypothesis. The F_1 grain corresponded to the accepted description of the heterozygous fatuoid in all characters except lemma pubescence. In the F_2 of each cross Tschermak found but three types of segregates, namely, *fatua*, intermediate, and *sativa* forms, occurring in the ratio of 4:9:3, respectively.[4]

EXPERIMENTAL RESULTS

Materials and Methods

Reciprocal crosses between *Avena fatua* and *A. sativa* were attempted at the University of Alberta, Edmonton, in 1929. Four hybrid seeds were obtained, all of which were from hybridizations performed with *A. fatua* as the maternal parent.

The *A. fatua* parents used were stray plants of the common black or brown wild oat, which grew adjacent to experimental plots at the University. Seeds of each of these plants were collected and grown separately in parental check plots for three years. The type appeared to be uniform and free from genetic variation. The grain of *A. fatua* is characterized by a large, oblique, "sucker mouth" articulation; by heavy pubescence on rachilla, callus, and lemma; by dark brown or black lemma color; and by strong, geniculate awns on all grains of the spikelet. Other characteristics which distinguish this wild form are delayed germination, early maturity, ease of shattering at maturity, and fine, drooping panicle branches.

The *A. sativa* parent, Selection No. 76, contrasts markedly with the A. fatua parent in all grain characters. The articula-

[4] Tschermak infers that segregation in the above ratio occurs when the heterozygous fatuoid is tested, for the heterozygous fatuoid is compared directly to the F_1 both in morphology and in breeding behavior.

tion is small, not oblique; the rachilla and callus range from glabrousness to a very sparse, short pubescence; the lemma is white and glabrous; and the development of awns has not been noted in seven years of close observation. Selection No. 76 has the distinction of having never been known to give rise to fatuoids.

The F_1 plants were grown in the greenhouse during the winter of 1929-30. The F_2 consisting of four populations with a total of 69 plants was grown in the field in 1930. The different populations showed the same type of segregation and were, therefore, treated as one group in the final analysis. The F_3 was grown in the greenhouse in 1932.

Inheritance of Differential Grain Characters

Particular stress was placed upon the study of the mode of inheritance of the grain characters for which fatuoids deviate from the normal type; namely, pubescence of callus and of rachilla, development of awns, and type of floret articulation. These characters shall hereafter be referred to as the "fatuoid complex." The modes of inheritance of lemma color and of lemma pubescence were also studied.

The F_1 plants of the *A. fatua-A. sativa* cross were intermediate between the parental types for all characters of the complex. Black lemma color proved to be dominant. The F_1 corresponded to the heterozygous fatuoid in all characters of the complex, differing only with respect to lemma color and lemma pubescence.

The F_2 plants exhibited practically all gradations between the parents in pubescence and awn development. In lemma color there were three distinct types, black, gray and white. In the case of articulation, three more or less distinct types were produced, namely, *fatua*, intermediate, and *sativa*

Each of the characters of the fatuoid complex was studied for its individual inheritance as well as for its genetic relationship to other characters of the group. Lemma color and lemma pubescence were also studied both separately and in relation to other grain characters.

The character of the complex were each found to be inherited on the basis of a single factor when considered separately. In studying the correlations between these characters, it was found that very close linkage existed between them. It would appear, therefore, that the characters of the fatuoid complex are governed by a single gene or by a closely linked complex of genes. Dominance was incomplete, the homozygous genotypes producing parental expressions, while the heterozygous state produced intermediate expressions.

Lemma pubescence was found to be completely linked with the complex, but expressed only in the case of black segregaties.

Lemma color, on the other hand, was found to be governed by two genetic factors, both of which were independent of the gene governing the fatuoid complex.

These results are in general agreement with data of other investigators.

The reader is referred to Florell (2) for a review of the literature on the genetics of floret articulation, and to Johnson (9) for a recent review of the literature on the genetics of awn development, rachilla pubescence, and lemma color.

Combined Inheritance of the Fatuoid Complex and Lemma Color

After each character had been studied for its individual mode of inheritance and for its genetic relationship to the other characters, the task of devising a single scheme of inheritance for the entire group of characters was undertaken.

It has been shown that the inheritance of rachilla pubescence, lemma pubescence, callus pubescence, articulation, and awn development are governed, essentially, by a single genetic unit. This single unit conditions three general types, *fatua, intermediate,* and *sativa*. The two factors for lemma color, operating independently of the unit governing the fatuoid complex, produce color types within the general types. Thus the following phenotypes may

be expected: black, gray, and white *fatua* types; black, gray, and white intermediate types; and black, gray and white *sativa* types.

Based on observed data, the following factorial interactions and representations are assumed:

B—an epistatic factor for black lemma color.

G—a factor for gray lemma color, which is epistatic to b or g or both, but hypostatic to B.

W—a gene complex controlling awn development, articulation, and lemma, rachilla and callus pubescence; WW produces *fatua*, Ww intermediate, and ww *sativa* types.

The following symbols are given to the various expected phenotypes:

BW, black fatua	BI, black intermediate	Bw, black sativa
GW, gray fatua	GI, gray intermediate	Gw, gray sativa
bW, white fatua	bI, white intermediate	bw, white sativa

A hypothetical inheritance scheme may now be stated as follows:

P_1 BBGGWW x bbggww
(BW) (bw)

F_1 BbGgWw
(BI)

F_2 Genotype	Phenotype	F_3 segregation
(1 BBGGWW	BW	Homozygous BW
(2 BbGGWW	BW	3 BW:1 GW
(2 BBGGWw	BI	1 BW : 2 BI : 1 Bw
(2 BBGgWW	BW	Homozygous BW
(4 BbGGWw	BI	3 BW:6BI:3Bw:1GW:2GI:1Gw
(4 BBGgWw	BI	1 BW:2BI:1Bw
(4 BbGgWW	BW	12 BW:3GW:1bW
(8 BbGgWw	BI	F_2 segregation repeated 12 BW:24BI:12Bw:3GW:6GI:3Gw 1 bW:2bI:1bw
(1 BBggWW	BW	Homozygous BW
(2 BbggWW	BW	3 BW:1bW
(2 BBggWw	BI	1 BW:2BI:1Bw
(4 BbggWw	BI	3 BW:6BI:3Bw:1bW:2bI:1bw
(1 BBGGww	Bw	Homozygous Bw
(2 BbGGww	Bw	3 Bw:1Gw
(2 BBGgww	Bw	Homozygous Bw
(4 BbGgww	Bw	12 Bw:3Gw:1bw
(1 bbGGWW	GW	Homozygous GW
(2 bbGGWw	GI	1 GW:2GI:1Gw
(2 bbGgWW	GW	3 GW:1bW
(4 bbGgWw	GI	3 GW:6GI:3Gw:1bW:2bI:1bw
(1 BBggww	Bw	Homozygous Bw
(2 Bbggww	Bw	3 Bw:1bw
(1 bbGGww	Gw	Homozygous Gw
(2 bbGgww	Gw	3 Gw:1bw
(1 bbggWW	bW	Hoomzygous bW
(2 bbggWw	bI	1 bW:2bI:1bw
(1 bbggww	bw	Homozygous bw

Collecting the F_2 phenotypes in the proceeding scheme, the phenotypic F_2 ratio is found to be 12BW:24BI:12Bw:3GW:6GI:3Gw:1bW:2bI:1bw.

The actual F_2 data conform fairly well to theoretical frequencies calculated on the basis of the preceding hypothesis. The x^2 test for the goodness of fit of observed and calculated ratios is given in Table 1.

TABLE 1. Segregation for lemma color and the fatuoid complex in the F_2 form a cross between A. sativa and A. fatua, and comparison with a theoretical 12:24:12:3:6:3:1:2:1 ratio by the x^2 method.

Phenotype		F_2 frequencies		O-C	$(O-C)^2$	$\frac{(O-C)^2}{C}$
		Observed	Calculated			
Black, fatua	BW	14	12.94	1.04	1.08	0.083
Black, intermediate	BI	21	25.87	4.87	23.72	0.917
Black, sativa	Bw	19	12.94	6.06	36.72	2.838
Gray, fatua	GW	1	3.23	2.23	4.97	1.539
Gray, intermediate	GI	4	6.47	2.47	6 10	0.943
Gray, sativa	Gw	6	3.23	2.77	7.67	2.375
White, fatua	bW	1	1.08	0.08	0.06	0.056
White, intermediate	bI	3	2.16	0.84	0.71	0.329
White, sativa	bw	0	1.08	1.08	1.17	1.083
Total		69	69.00			$x^2 = 10.163$

$P = 0.2547$

The P-value of O.2547 indicates fair conformity between the observed and calculated frequencies. Analysis of F_3 data gave further support to the validity of the hypothesis by disclosing a close correspondence between the observed and the expected F_3 behavior.

Relation of the *fatua-sativa* Cross to the Origin of Fatuoids

The appearance of three heterozygous fatuoid types (bI) and one homozygous fatuoid type (bW) as Mendelian segregates in the F_2 is especially noteworthy since it gives definite proof that these types may originate as the result of hybridization between *A. sativa* and *A. fatua* In morphological characteristics and in breeding behavior these "synthetic" fatuoid types correspond exactly to the accepted definition of fatuoids. (See Fig. 1, also inheritance scheme.)

It is significant to note at this point that natural hybridization occurs between *A. fatua* and *A. sativa* with sufficient frequency to account for the observed occurrences of fatuoids. At the University of Alberta in 1932 it was found that when *A. fatua* and *A. sativa* (Victory) were grown in adjacent rows there occurred 0.362 per cent natural crossing in the *A. fatua* and 0.056 per cent in the *A. sativa*

Segregating types have frequently been observed, together with fatuoids, in Alberta oat fields. A number of these types have been tested and shown to be segregates from a *fatua-sativa* cross.

DISCUSSIONS AND CONCLUSIONS

It has been demonstrated that there are two grain types occurring in the segregation from *A. fatua* x *A. sativa* crosses, which are both morphologically and genetically identical with heterozygous and homozygous fatuoids, respectively.

The opponents of the natural crossing hypothesis may contend that these grain types are not true segregates from the cross, but that they have originated through chromosome aberration as a result of chormosomal incompatibilities introduced by the interspecific nature of the crosses. Huskins (8) has recently stated that "the origin of fatuoids or speltoids from crosses of *A. sativa* and *T. vulgare* with other species of oats or wheat, respectively, is of course expected on the chromosome aberration explanation, especially since hybridization increases the frequency of irregular pairing. But the origin of fatuoids in the progeny of inter-

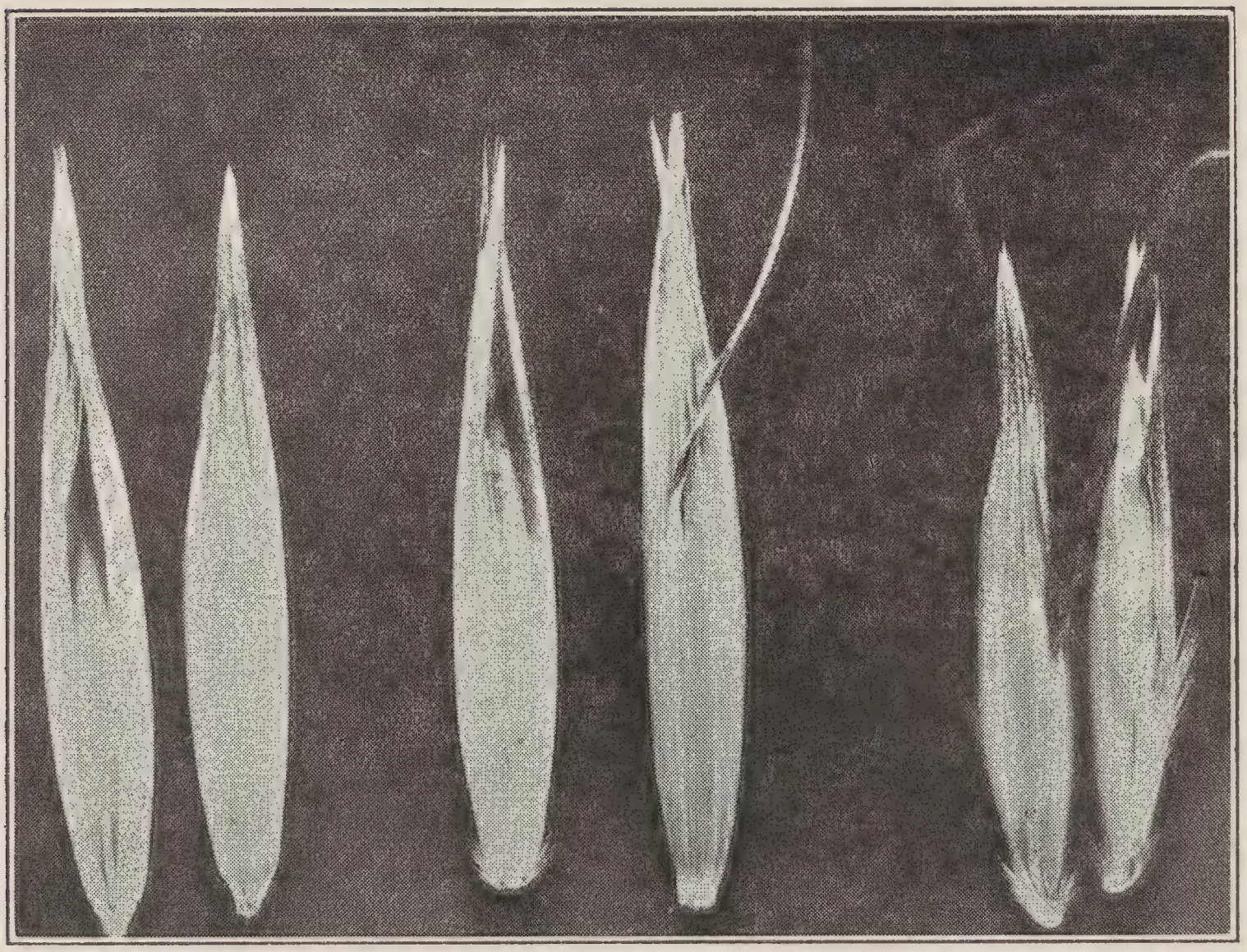

Fig. 1. **A. fatua** x **A. sativa**, white segregates F_2. Left to right in pairs: **sativa** (bw), intermediate (bI), and **fatua** (bW) types. In morphology and breeding behavior, the intermediate type is identical with the heterozygous fatuoid and the **fatua** type is identical with the homozygous fatuoid. (From Aamodt, Johnson, and Manson.)

varietal or interspecific crosses by no means supports the earlier hypothesis of Tschermak and others that crossing between *A. sativa* and *A. fatua* is the cause of their origin. It is rather an incidental issue that they sometimes arise from such crosses." Close study of the results of the present investigation will show that such a contention is untenable. The presence of a single genetic factor for articulation; the existence of a very close linkage relationship between the factor for articulation and the factors for awn development, rachilla pubescence, and callus pubescence: and the presence of two factors for lemma color which are independent of the linkage group: these facts make segregation for the two fatuoid types in *A. sativa x A. fatua* crosses inevitable.

The point that must be explained is not the appearance of the fatuoid type, but the more or less complete selective elimination of segregates other than fatuoids. In the material investigated the fatuoid types occurred with relative rarity in the segregating population; the various black and gray types were far more numerous. How is it then that fatuoids are not found in association with a host of black and gray off-types? The answer is that fatuoids have been found with considerable regularity in association with these other aberrants. This is particularly true in fields grown from seed stocks which have not undergone selection for a considerable time. Field inspectors state that these types are of common occurrence throughout the country, particularly in districts where unselected seed is used. One inspector tells of observing many bushels of oats in which segregating types were as numerous as the *Sativa* types. A small percentage of the segregates were what are commonly called fatuoids. Workers at the University of Alberta, and several private seed growers, have found it necessary from time to time to remove black and gray off-types, in addition to fatuoids, from

registered seed stocks. It is undoubtedly true, however, that in well-selected seed stocks, such as are found at experiment stations and on seed farms, fatuoids are usually found unassociated with other off-types. When selection is practised in a field or plot, the black and gray segregates from a natural cross would be readily observed and removed, the homozygous fatuoid types would usually be noticed by their very strong awns and also be removed; but the heterozygous fatuoid type, similar in all characters to the cultivated parent, would in many cases escape notice and be propagated with the selected seed stock. In varieties in which a fairly strong awn development normally occurs, it would be particularly difficult to notice the heterozygous fatuoid type.

It seems safe to conclude that fatuoids arise through natural hybridization between *A. fatua* and *A. sativa*. But such a conclusion need not exclude the possibility of other means of origin. Chromosome incompatibility, either in hybrid or in non-hybrid populations, might sometimes produce fatuoids through chromosomal aberration. On the other hand, a point mutation in the gene or gene complex which controls the characters involved might also occasionally produce fatuoid plants. The results reported in the present paper are not held to refute the chromosome aberration and mutation theories; but they are held to prove that hybridization between *A. fatua* and *A. sativa* is, at least, one of the ways in which fatuoids may originate.

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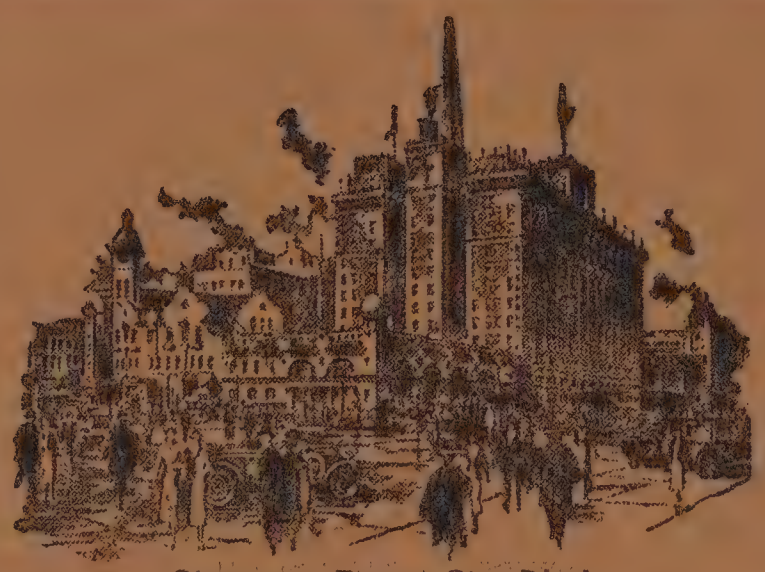

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Entered as Second Class Matter, April 5, 1927, at the Postoffice at Cheney, Washington. Office of Publication, Cheney, Washington. Subscription Price to Members, Including Dues, One Dollar per Year; to Non-Members, One Dollar.
Volumes I. to IX., 1927 to 1935, Each $1.25

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-:- EDITORIAL COMMENT -:-

INLAND EMPIRE

Geographical names have a way of being appropriated, of being misapplied. In general this may matter little. Aptness or even inaptness may be excellent reasons for retaining a name. When a name is applied to a region a consensus of opinion of inhabitants may help determine what should be included. At present there is little agreement as to what is meant by the Inland Empire of the Northwest. Citizens of Pasco, Washington, might be greatly surprised to find the cities of Pocatello, Missoula or Fernie considered themselves a part of it. Discussion by readers of Northwest Science as to what area should be included is invited. It was proposed in a meeting of Northwest Scientific Association (1934) that the area drained by the Columbia River above the Bonneville Dam be fixed as that to which the term should apply. There are excellent biological reasons for this. Also, as the "hinterland" of The Dalles, it is historically correct. What have others to say?

College men are apt to think with some justification of institutions of learning as the chief places where scientific research is found. Members of Northwest Scientific Association will compare quite favorably with any other group of scientists not wholly given to research in the output of work. There are perfectly obvious reasons why most of this work is of a minor character. (Let it be remembered that there is a constant selecting for more lucrative positions from here and elsewhere, while none of these positions are in this region.) Officers of the Pacific Division of the American Association for Advancement of Science question the advisability of accepting the invitation of Spokane for a meeting with the parent association because no university doing research is located in this city. Indeed, we may lack something of the atmosphere to which influential members of that organization are accustomed. However, when applications of science are considered, and with applications must go much original research, few regions offer more than the Inland Empire of the Northwest. Here are headquarters of the newly-assembled Soil Conservation Service for the Northwest, with some four hundred trained field men. From here the fight against White Pine Blister Rust is directed for the entire West. A large group of Forestry men devoted to research find time to meet with the N. W. S. A. Meteorological research has a station of importance adjacent to Spokane. Perhaps in no similar area of the nation is concentrated so much of up-to-the-minute interest in mining. Horticultural and general agricultural interests have strong research staffs. Geological problems simply jump out of the ground at the observer. On our western border is in progress the most expensive biological experiment ever undertaken, where the U. S. Bureau of Fisheries hurries to complete an untried plan to save the entire salmon population of the Columbia River from an over-hasty building program. Five state colleges, individually, because of their size and isolation, may never have the part of host to the American Association for Advancement of Science, but individually and collectively they have much indeed to offer the association devoted to the advancement of scientific research and the diffusion of scientific knowledge.

Let us join wholeheartedly to make the Vancouver Meeting in 1940 one of the best of the Summer Meetings, but let us leave nothing undone to bring the American Association to the Inland Empire at an early date. This may be disseminating scientific knowledge to the disseminators.

RESEARCH FUNDS

A. A. A. S. FUND FOR RESEARCH amounting to fifty dollars, repeating the donation from that source of last year, is announced by Secretary Freeman. This is an action on the part of the Affiliations Committee, of which Dr. B. L. Livingstone of Johns Hopkins University is Chairman, to give encouragement to research through the Affiliated Academies of Science and other organizations affiliated with the American Association. The present would be an opportune time for those desiring to give aid to workers in science to come forward with subscriptions, as was done last year when the A. A. A. S. fund was received. Workers having projects in progress would do well to send applications, with descriptions of their projects, to Chairman E. M. Keyser of the Board of Trustees for consideration.

SEP 29 1939

Fuel Type Mapping, Its Relation to Forest Fire Control Planning

By L. G. HORNBY

Northern Rocky Mountain Forest and Range Experiment Station

The most recent and most definite statement of the fire-control objective in Region I, is "to stop the spread of every fire within the first work period." A previously accepted statement of the objective was in terms of an allowable percentage of burned area, assigned to each forest type according to the intensity of potential fire damage. Judged by that standard, the region's fire record has been highly satisfactory. Since the burned area in each type would easily have been limited to the allowable percentage if the few very large fires had been controlled at small size, and since only the exceptional fire attains great size during the first work period, these two objectives interpreted into action are approximately the same. If either objective is to be reached, the importance of reliable fuel classification cannot be stressed too strongly.

The materials in which forest fire control engineers operate are fuels. Forest fuels exhibit differences as to rate of fire spread and resistance of fire to control, and these differences vary with moisture conditions and with wind velocity. Thirty years of fire-control experience has shown that satisfactory suppression requires considerable preparedness. The preparations deal with the coordinated placement of man power and of such facilities as roads, trails, landing fields, and lookouts. In a broad sense the man power and facilities constitute the fire-control structure. After fuels are classified and the characteristics of each class studied, a structure can be designed which will meet the protection and requirements. Obviously, maps showing the location and extent of the different classes of fuel are essential.

In Region I, fortunately, fuel mapping was begun in 1930, early enough to guide the very large construction program still being energetically pushed in northern Idaho and western Montana. Fuel type maps have been prepared and used in the development of fire-control plans for 15 million acres of national forest lands in the region.

In midsummer, when burning conditions become extreme, the maximum number of detectors, smokechasers, and crews provided for are placed at their stations. Under such conditions the occurrence of a fire in fuels in which fire spreads rapidly, or of which the volume is so large as to retard fire-line construction, tests the organization. If the attack is begun too late or with too few men the intense heat and smoke at the front of the fire may prevent initial control action from succeeding, even with the best possible application of brains and brawn. If the initial attack fails, the fire sweeps a path of destruction until conspicuous changes retard its progress. Such changes may be in fuel, topography, wind, or moisture, or in some combination of these factors. Fires usually die down in late evening. By delivering hundreds of laborers rapidly during the night and attacking by daylight, control may be effected before burning influences of the next mid-day cause destruction over a much larger area. The fuel type in which the fire is burning determines, in large measure, the size of the control job which must be met.

In fuel-type mapping in Region I, emphasis has been placed on the relation of character of fuels to effective control by the first-line or smokechaser organization. The mapper of fuels is concerned only with what a fire will do during the time normally adequate for travel and control by nitial attacking force, i. e., in the first two or three hours after it is large enough to be discovered. After a fire has attained speed it is no respecter of small differences in fuel, moisture or protection from wind, and usually it requires reinforcements. Class of fuel de-

termines what time will be available for raeching a fire and hence what distance is allowable between any potential fire and a man-power station. Although fuel-type mapping has been based on average of worst burning conditions, the final fire-control plan recognizes that travel time allowances must be varied to meet changes in weather conditions. Therefore, travel time standards to meet average as well as worst weather conditions have been worked out for every fuel type.

The rate at which a fire spreads determines how many feet or chains of perimeter will be produced per hour. Amount, size, arrangement, and species of fuel along the perimeter of the fire, together with slope and soil, determine resistance to control, or the number of man-hours of work required for each foot or chain of fire line. Obviously, the number of man-hours required per chain multiplied by the number of chains to be worked gives the fire-fighting job to be done. The fuel maps show, by appropriate symbol, the probable rate of spread and the probable resistance to control.

The volume and condition of fuels change. After every fire or new insect attack, the fuel type map will have to be corrected. (Fortunately, changes involving any large area take place slowly.) Firemen and expensive improvements such as roads, trails, telephone lines, and buildings cannot be relocated annually. Fuel mappers are expected to predict and classify the condition of each fuel as it will be five years after examination.

The mapper takes into consideration all the different initial rates of spread that could occur in the region. Eliminating the extreme class likely to occur in such abnormal conditions as areas of unburned logging slash and so-called "jack pots" in old burns, he divides the remaining rates into three equal classes called low, medium, and high, and assigns each fuel he encounters to one of these classes.

In classifying fuels the probability of spotting ahead is of prime importance. Therefore, higher rates of spread must be anticipated where snags, slash, and windfalls are present.

Where large fires have stopped naturally the mapper should not assume that the amount and kind of fuel present, under drought conditions, accounted for the fire's dying out. Precipitation, high humidity, change of wind direction, and night cooling, working singly or in combination, have frequently been the cause, rather than fuel conditions.

Evidence as to cause for different rates of spread is available in very consistent data collected at widely separated forest experiment stations in the United States. These data are in the form of measurements of fuel moisture content, solar radiation, and wind movement as influenced by shade, by obstruction to air movement, and by direction and degree of slope.

At the Priest River Experiment Forest, on the Kaniksu National Forest, Idaho, Gisborne has established three weather stations about 500 feet apart in a line approximately parallel to the prevailing wind direction. All are on a flat that originally bore a dense overmature stand of the white pine-hemlock type. The wind and sun have full access to the station farthest south, where the timber was clear cut. Northward, with the wind, the next station is on an area where cutting has reduced the density of the forest canopy by half. Around the third station the natural forest remains untouched, protected from the wind by about 500 feet of half-cut timber plus 300 feet of virgin timber. It is evident that after a month of continuous midsummer drought most of the differences in daily weather records at these stations must be attributed to differences in density of stand.

The week August 10-16, 1931, was selected for study because it was in the worst part of a disastrous fire season and no precipitation complicated the evidence.

From 8:00 a. m. to 6:30 p. m. temperature was found to be high and humidity low according to openness of stand. After-

noon wind velocity at the clear-cut station was 20 times that in full timber. Obviously rate of combustion and hence rate of fire spread, is increased by openness of stand.

Conclusions agreeing with these, but applying to the northeastern United States, were published by Paul W. Stickel in "Pulp and Paper" of Canada, January, 1933.

The following information is given for Colorado by Carlos G. Bates in his article "Transect of a Mountain Valley" published in Ecology, January, 1923.

"A transect of this valley (700 feet north to south from ridge to ridge) was made, running as nearly as possible normal to the contours of both slopes, in a straight line, and on this line, stations were located arbitrarily at intervals of exactly 50 feet.

"All of the south exposure is subjected to direct insolation at some time during the day and during the entire year. As a result of this insolation, high maximum temperatures are recorded at the surface of the soil, the highest during 1921 being nearly 150° F. and being fully 60° above that of the coolest neighboring site.

"The extreme top portion of the south exposure . . . shows almost as thorough drying of the surface soil as any other portion, but appreciably lower temperatures.

"From the bottom of the valley to almost the top of the north exposure relatively moderate temperatures are experienced, both on account of the angle of incidence of the sun's rays and the completeness of the cover. On the lowest and also steepest portion of the north exposure, the evaporation rate is lowest, the soil temperatures are lowest, the accumulation of moisture is greatest, and the drying of the soil is most gradual. . . .

"The upper portion of the north exposure becomes progressively warmer and drier."

An exhaustive study in Region I of rates of spread of fires, starting in green timber of pole size or larger, that occurred in the period 1921-30, showed with remarkable consistency that they were dependent upon density of timber stand. Unfortunately, timber type does not determine the rate of spread or resistance to control at a particular spot. Density of cover and amount and condition of fuels vary tremendously within a given type. The age of the trees, the number of snags, or the presence or absence of moss on the trees often means more than timber type. Aanalysis shows that specific fuel conditions unrelated to forest type have exerted 3 to 15 times as much influence on initial rates of spread as has type.

Resistance to control, as stated previously, is an expression of the amount of work required per chain, or other unit, of fire perimeter. The degrees of resistance mapped are designed in the same terms used for rates of spread—low, medium, high, and extreme. The important factors in degree resistance are:

	standing green timber
	snags
Fuel Conditions Existing in	windfall and slash
Amount	brush, reproduction and grass
Distribution	duff and roots
Size	
Species	
Decay	
Trenching and Dirt-Smothering Chance as Affected by	
Roots	
Soil	
Rocks	
Slope	

In rating resistance, only the work required to corral fires and hold them through the mid-day burning period is judged. In situations such as under dense

oil stands, particularly on north slopes and protected flats, small fires in deep duff and rotten logs require a large amount of work before they are entirely extinguished, but a relatively small amount of work suffices to prevent their escape.

A fuel mapper assumes the method of attack to be by ordinary handwork with the most suitable tools. He should endeavor to visualize an efficient fireman doing whatever work would be needed at the spot under consideration.

At five training camps for fuel mappers 90 men representing 10 national forests of Region I, agreed on 42 ratings to be assigned to typical fuels of the region. These ratings have been used as a guide in building up the comprehensive classification scheme illustrated in table 1.

A weakness of this method of rating fuels is that estimates are accepted in lieu of accurate measurements. After years of measuring influences, it may be possible to predict rate of spread for each possible combination of fuel species, vol-

TABLE 1
EXAMPLES OF FIRE SPREAD AND RESISTANCE RATINGS FOR VARIOUS KINDS OF FUEL[1]

Example number	Description of fuel	Rate of spread	Resistance to control
	Ponderosa pine, mature stands on SW slopes		
1	with reproduction scattered or absent	H	L
2	with reproduction moderately dense....	H	W
	Mature, normally dense stands of spruce, white fir, or cedar-hemlock in protected bottoms. If rought snags are conspicuously present and green trees are limby, connecting ground fuels with		
3	moss in crowns	L	H
	Stands where snags are smooth and thinly scattered and		
4	green trees are clean of moss and brushy limbs	L	L
	Normally dense stands of white pine, larch-fir, Douglas fir, or lodgepole pine in which windfalls and snags are almost absent and ground vegetation is conspicuously		
5	low shrubs (1) on protected flats and NE exposures;	L	L
	(2) on exposed flats and gentle SW slopes usually with increased openness and prevalence of grass, with snags and windfalls moderately		
6	abundant but not continuous	M	M
	Mature dense stands, or any species except ponderosa pine, 80 per cent killed by ground fire or epidemic leaving all dead foliage on trees, in which half or more of dead trees are down and not completely shaded by reproduction		
7	on exposed SW slopes	E	E
8	on protected NE slopes	H	E
9	on exposed SW slopes if fine fuels were consumed	H	H
10	on protected NE slopes	M	H

[1] E = extreme; H = high; M = medium; L = low.

ume distribution, continuity, slope, shade, wind, and days since 0.1 inch of rain. In the meantime, preparations will have to be made and fires will have to be fought.

In Region I in the past 10 years accurate inventories of certain fuel conditions have been made in many places. Such items have been recorded as exposure, slope, amount and size of dead material standing and down, percentage of trees affected by rot, and number of green stems per acre by size classes. If such data are to be used someone must determine what they mean in terms of fire behavior and fire-fighting and must express these meanings in concise summary terms ready for instant use by dispatchers. The method described here eliminates the detailed inventory step as superfluous on the assumption that men experienced in the behavior of small fires can draw conclusions more accurately while looking at fuels than while looking at descriptions of them. This method is subject to refinement as usable data become available.

The fuels on 15 million acres of land in Region I have been mapped on a scale of 1 inch to the mile. Field mapping was done by men working alone. The rate of mapping varied from three to seven sections per day. The degree of accuracy attained has been found satisfactory for fire-control planning at the present stage. Continuous revision will be needed.

Mapping on a scale of 2 inches to the mile will be desirable whenever base maps provide sufficient detail to permit accurate and easy location of small areas on the ground. This scale is consistent with the accuracy to which the locations of fires can be determined with lookout instruments.

Annual Meeting of Northwest Scientific Association

The Northwest Scientific Association will meet for its annual two-day program meeting at the Davenport Hotel, Tuesday and Wednesday, December 29-30, 1936. Speakers for the general session will be announced in the November issue of "Northwest Science." Section programs will be given with the following eight sections. Members having titles that they wish to present may forward them to the proper chairman. It is expected that a December issue will announce the entire program early enough to reach members before their vacations begin.

Bacteriology-Public Health—Chairman, Dr. W. V. Halverson, University of Idaho, Moscow, Idaho.

Botany-Zoology—Chairman, Professor Charles W. Waters, University of Montana, Missoula, Montana.

Chemistry-Physics-Mathematics — Chairman, Professor W. H. Bunch, University of Idaho, Moscow, Idaho.

Engineering—T. H. Judd, Washington Water Power Co., Spokane, Washington.

Forestry—Chairman, H. T. Gisborne, Forest Experiment Station, Missoula, Montana.

Geology-Geography—Chairman, Dr. Vernon E. Scheid, University of Idaho, Moscow, Idaho.

Psychology-Education—Chairman, Dr. H. H. Fuller, 1608 W. 9th, Spokane, Washington.

Social Science—Chairman, Professor Clifford D. Jacobs, Washington State College, Pullman, Washington.

Preparation is being made for a strong general program. It is hoped that members having research work in progress or completed reports which have not been offered previously will join in making interesting Sectional Programs.

O. W. FREEMAN, Secretary.

The Detection and Estimation of Chlorate in Soils by the Thiocyanate Test Paper Method*

By R. P. d'URBAL, Assistant Chemist, and H. R. OFFORD, Pathologist

Division of Plant Disease Control, Bureau of Entomology and Plant Quarantine, United States Department of Agriculture.

The extensive use that has been made of chlorate compounds for weed-killing purposes in recent years has frequently necessitated control tests on the capacity of different soils for retaining and altering chlorate, to the end of predicting toxic doses and of testing subsequent sterility of the soil. Field and greenhouse tests of this nature have been undertaken by the writers as part of the program of method improvement in the chemical eradication of Ribes (sp.), the host plants of the destructive blister rust disease (*Cronartium ribicola Fisch.*) of white pines. In the past, these control tests have been made by colorimetric methods such as the aniline hydrochloride[1], and by gravimetric[2] or volumetric methods[3]. But these methods for chlorate detection have proved to be inconvenient for the rapid examination of a large number of samples and cannot conveniently be employed away from the laboratory.

Work just completed has shown that the recently published ammonium thiocyanate test paper method[4] is both rapid and dependable for the detection and estimation of chlorate in soils. The procedure has a distinct advantage over other methods for chlorate detection in that it may be readily used under field conditions for qualitative and rough quantitative work. Under field conditions satisfactory tests may be obtained for 50-100 P. P. M. (0.05 to 0.10 mg. per cc.) or more of sodium chlorate in unclarified soil extract. In laboratory work the sensitivity of the method results in a positive test for as little as 30-50 P. P. M. (0.03-0.05 mg. per cc.) of chlorate in colorless or clarified extracts. Satisfactory clarification of soil extracts is obtained by filtration after the addition of powdered copper sulphate and a small excess of calcium hydroxide. By concentrating the soil extract to a small volume, it is possible to detect mere traces of chlorate.

The method was tested on clarified and unclarified extracts made from the following classes of soils: Sand, fine sandy loam, sandy silt loam, silt loam and clay. The procedure was also tested on German peat, on silt loam previously deflocculated with sodium chlorate, and with silt loam combined with compost and with manure. Notations on these soils and soil mixtures and data on the recovery of chlorates are given in table 1.

PREPARATION OF SOIL EXTRACTS FOR ANALYSIS

Separate portions of soil are produced with a soil augur at various depths and from several parts of the plot. Usually it is of interest to sample a plot on the basis of at least two horizons, for example, a surface sample 0-4 inches in depth and a lower horizon 4-10 inches in depth. If the analytical tests are to be made in the field, the procedure described under Field Analysis should be followed for preparation of the soil extracts. Specimens for laboratory analysis are placed in stoppered containers of the type commonly employed in soils work. They should be stored under refrigeration until extracted and analyzed. It is advisable to prepare extracts within 24 hours after collection in order to avoid loss of chlorate.

FOR LABORATORY ANALYSIS—To a 100-200 gm. sample of soil add a meas-

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*This work has been made possible through the cooperation of the School of Forestry, University of Idaho, Moscow, Idaho, and the College of Agriculture, University of California, Berkeley, Cal. Thanks are due the Division of Plant Nutrition, University of California, for furnishing soil samples from Hamilton, Fresno and Oakley, Cal.

TABLE 1

SUITABILITY OF THE THIOCYANATE TEST PAPER METHOD FOR DETECTION AND ESTIMATION OF CHLORATE IN SOILS

Soil Type	Percent Water in Soil Prepared for Extract	Color of Filtered Extract	Typical Recoveries of Sodium Chlorate from Clarified Extracts* (mgs. per cc.)		Lowest Quantity** of Sodium Chlorate (mgs. per cc.) Giving a Positive Test in:	
			Added to Soil	Recovered from Soil	Unclarified Cold Water Extract	Clarified Cold Water Extract
German peat	85.7	Amber	0.03 0.05	0.02 0.04	0.07	0.03
Palouse silt loam plus compost (a)	52.5	Amber-brown	0.04 0.19	0.05 0.25	0.10	0.03
Palouse silt loam plus manure	43.5	Reddish-amber	0.03 0.10 0.50	0.02 0.08 0.55	0.10	0.03
Deflocculated (b) Palouse silt loam	43.5	Turbid Yellow-brown	0.03 0.10 0.50	0.05 0.10 0.50	0.10	0.03
Organic-rich fine sandy loam (c)	70.0	Light-amber	0.03 0.10 1.00	0.02 0.15 1.00	0.05	0.03
Palouse silt loam	36.0	Colorless	0.03 0.08	0 04 0.07	0.03	0.03
Sandy silt loam (d)	46.0	Colorless	0.04 0.22 1.40	0.05 0.25 1.50	0.03	0.03
Oakley sand (e)	54.8	Colorless	0.05 0.08 0.10	0.05 0.05 0 08	0.03	0.03
Fresno light, very fine sandy loam (f)	51.0	Colorless	0.05 0.08 0.10	0.07 0.10 0.15	0.03	0.03
Hamilton clay (g)	52.0	Colorless	0.05 0.08 0.10	0.05 0.05 0.10	0.03	0.03

*Controls on untreated soils were included with each test and resulted in a negative test for the chlorate ion.

**Positive tests were obtained with extracts of the above soils containing 0.005-0 01 mgs. of sodium chlorate upon evaporation on a steam bath to a tenth of their original volume. Sensitivity of test as shown in columns 6 and 7 of Table 1 refer to non-concentrated soil extracts.

(a) All Palouse soils collected from vicinity of University greenhouses, Moscow, Idaho.

(b) This soil was deflocculated by a heavy application of sodium chlorate in the spring of 1933; it contained no chlorate at the time of the present tests.

(c) A granitic soil collected from the vicinity of Strawberry, Stanislaus Forest, Cal., in the sugar pine region. This soil contained a high percentage of organic material including coarse particles of conifer needles.

(d) An alluvial silt loam collected from Elk Creek, near Elk River in the white pine region of northern Idaho.

(e) Collected from the O'Hara property, Oakley, Cal.

(f) Collected from the Cristensen property, Fresno, Cal.

(g) Collected from the property of James Mills Orchard Corporation, Hamilton, Cal.

ured quantity of water sufficient to make a thick paste (about 1 part of soil to 1 part of water), mix thoroughly, and allow to stand for 30 minutes. Transfer the moistened sample to a Buchmer funnel covered with a No. 5 Whatman paper and filter under gentle suction. The extract, unless colorless, is clarified according to the following procedure: Add finely powdered copper sulphate at the rate of 0.1 gm. per 10 cc. of extract and shake until the chemical has dissolved; then add a slight excess of powdered calcium hydroxide, again shake and allow to stand for a few minutes; filter off the precipitated cupric hydroxide and the organic water. The resulting alkaline filtrates are stable if kept tightly stoppered and may be held over for several days without loss of chlorate. If exploratory tests show that the extracts contain less than 0.03 mg. of chlorate per cc. they should be concentrated to approximately one-tenth of their original volume. Extracts may be concentrated without loss of chlorate by first adding a small amount of sodium carbonate or calcium hydroxide (enough to ensure that the extracts are alkaline), and then evaporating carefully on a steam bath. If necessary, the concentrated extract should be clarified.

FOR FIELD ANALYSIS—Mix thoroughly measured quantities of soil and water in the proportions that will permit the extract to be filtered through a folded filter without the aid of suction. For sandy soils 1 part of soil to 1 part or less of water will furnish a filterable mixture. For loamy or clay soils, it will be necessary to increase the amount of water to as much as 2 parts of water to 1 of soil. Stir or shake the soil and water mixtures thoroughly and allow them to stand for 30 minutes before filtering through a folded filter. Extracts that are colorless, or pale in color, are then tested immediately for chlorate according to the directions given under Analytical Procedure. For heating the test papers any convenient equipment may be used, such as a wood, gasoline, or kerosene stove, or the surface of a gas or electric hot plate. If a hot plate is used the watch glass should be placed on a piece of asbestos or sheet metal elevated a short distance from the source of heat. A thermometer should be used to check the temperature to establish the limits of accuracy and sensitivity for the work as set forth under "Discussion." Highly colored extracts should be clarified with copper sulphate and calcium hydroxide as previously described.

ANALYTICAL PROCEDURE

PREPARATION OF THIOCYANATE TEST PAPERS—Impregnate Whatman No. 1 filter paper of convenient size by dipping in a 3 Normal solution of C. P. ammonium thiocyanate. The thiocyanate solution should contain about 0.0034 mg. of soluble iron per cc. to furnish test papers of maximum sensitivity. Unless the thiocyanate crystals produce a pale, rose-colored aqueous solution, the above quantity of iron should be added in the form of a few drops of a 0.1 per cent solution of ferric chloride. Dry the papers at a temperature not exceeding 70° C. on a cheesecloth frame suspended over a steam radiator. Test papers which are to be used for field work should be carried in a clean envelope; for laboratory use they should be stored in a dessicator. The papers should never be exposed to direct sunlight.

TEST FOR CHLORATE IN THE SOIL EXTRACT—The analytical test is made by adding one or more small drops of the colorless or clarified soil extract to the test paper, which is then transferred to a watch glass and heated at 98°-100° C. for 30 minutes or more. Best results are obtained when the papers are placed at once into the heating oven so that the drop of unknown solution is confined to the smallest possible area of the test paper. The presence of chlorate is indicated by the development of a pale lemon yellow to cadmium-yellow coloration of that portion of the test paper upon which

concentration of the chlorate has occurred.

For precise quantitative work it is necessary to prepare a series of standard stains by adding known amounts of sodium chlorate to an extract made from a chlorate-free soil similar to the one under investigation. The range of chlorate values chosen for standards will depend upon the particular problem under investigation and also upon the ability of the investigator in judging colors intermediate to the standards. A set of color standards such as 0.03, 0.05, 0.10, 0.25, 0.50, 0.75, 1.00 and 5.00 mg. of sodium chlorate per cc. will be found suitable for most laboratory work. A fresh series of standards should be prepared whenever a new supply of thiocyanate papers is made. For field work a standard color card will be found convenient and more permanent than mounted strips of standard test paper. This card is prepared by blending yellow and orange crayons to the exact colors equivalent to a suitable range of chlorate values.

DISCUSSION

Data in table 1 illustrates the sensitivity and accuracy of the test and have been selected from a larger body of data as being typical of routine work with the procedure. As shown by the figures in column 6, the presence of soluble or suspended colored material in extracts prepared from organic-rich soils, i. e., highly colored extracts, reduces the sensitivity of the test. Optimum sensitivity was obtained for all clarified extracts regardless of soil type. Reference to columns 4 and 5 of table 1 shows that, for clarified extracts, the accuracy of the procedure is satisfactory over a considerable range of chlorate content. Recovery of chlorate is more apt to be incomplete, or irregular, in the case of colored than in colorless extracts. Thus, if organic-rich extracts are rendered colorless by defecation, recovery of the chlorate tends to be less than theoretical. Improper or partial clearing of colored extracts usually results in chlorate values greater than theoretical because of the additional color contributed by the extract. This is especially marked in detecting chlorate in concentration of less than 0.20 mg. per cc. where the coloration produced by the chemical is not especially strong. While unclarified organic-rich extracts showed a tendency to increase the intensity of coloration in the presence of chlorate, control tests on the same extracts (to which no chlorate had been added) resulted in a negative test for chlorate ion. The characteristic yellow color of the analytical test was not produced by extracts obtained from any of the soils used in these experiments. Interfering substances[4] such as bromates, iodates, peroxides, persulphates, permanganates, dichromates and heavy metals (other than iron) are not usually encountered in soils work. In the present procedure heavy metals which might give conflicting coloration of test papers are removed by clarification. With the exception of soil type (b) as noted, none of the soils shown in table 1 had been treated with chlorate prior to the addition of the chemical in the laboratory test.

Clarification with copper sulphate and calcium hydroxide is recommended since the resulting extracts are alkaline and stable if protected from the air. If clarifying agents are used which result in acid extracts the latter should be analyzed at once or made alkaline before storing.

Maximum sensitivity of the test will not be obtained except by careful regulation of the temperature and duration of heating of the test papers. Temperatures lower than 95° C. and periods of heating shorter than 30 minutes produce unsatisfactory pink colors, while temperatures in excess of 105° C. and protracted heating result in a slight browning of the papers. If field equipment fails to regulate the temperature within ilmits of 10° C., quantitative tests will not be dependable, and qualitative tests may be indeterminate for concentrations of so-

dium chlorate of less than 0.10 mgs. per cc. By concentrating the soil extract, however, a qualitative test for chlorate can be secured with any type of heating device producing a minimum temperature of 90° C. and a maximum temperature that will not cause browning or charring of the test papers.

The role of iron in promoting the oxidation of thiocyanate by chlorate has already been suggested by Offord[4]. This point has been further studied in the present work, and it has been found that a paper which will turn a light pink color after a few minutes' exposure to humid air represents a paper of maximum sensitivity. Such a paper may be prepared by using a solution of ammonium thiocyanate containing 0.0034 mg. of iron per cc.

SUMMARY

A colorimetric procedure—the thiocyanate test paper method—has been found convenient and dependable for the rapid determination of chlorate in soils. In colorless extracts obtained from sand, silt loam, or sandy loam, 30 P. P. M. (0.03 mg. per cc.) of sodium chlorate gave a positive test. Soil mixtures which give strongly colored extracts such as manured Palouse silt loam, or German peat, must be cleared with copper sulphate and calcium hydroxide before equally satisfactory recovery of sodium chlorate can be obtained. The method can be used for qualitative and approximate quantitative work under field conditions.

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A new development by the Science Service and the Library of the U. S. Department of Agriculture at Washington seems to promise incalculable aid for research workers in localities where library facilities are limited. Arrangements have been completed by which any page of any book in the Library of the U. S. Department of Agriculture may be photographed on 35-millimeter cinema film for a very few cents. Thus, any article needed may be secured, complete, the purchaser assuming any risk of prosecution for violation of copyright. The exception will be articles or books in print less than one year.

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An Ecological Survey of Kamiak Butte

By LOWELL A. MULLEN

INTRODUCTION

Kamiak Butte is a quartzite prominence located 10 miles north of Pullman. It is 3 miles in length and at its highest point 1100 feet above the Palouse hills and 3650 feet above sea level. Because of a great diversity of exposures this small area offers the principal plant groups found in the entire region. The purpose of the survey was to determine something of the various types of vegetation as regards dominants, trends and direction of successions, light values, soil moisture and pH, and evaporation rates.

METHODS

Methods used were, for most part, conventional. Instruments for measuring habitat factors were: Friez soil-air thermographs (one placed on the south slope in an Agropyron-Festuca association, the other on the north slope in a *Pseudotsuga taxifolia* consociation), a Friez hygro-thermograph (placed on the ridge beneath a ponderosa pine), Livingston atmometers, Weston illuminometer, and a Youden H-ion concentration apparatus. Photographs were used extensively to record invasions, cover types, etc. Miscellaneous records were collected over a period of 4 years, and continuous detailed records for 2 years. The material to follow is presented in brief topical form, and concluded with a general summary.

VEGETATION

1. GENERAL ASPECTS

Two main types of plant cover are present: prairie and forest. In these two types are represented 3 life zones: Arid Transition timberless (Festuca-Agropyron prairie), Arid Transition timbered (*Pinus ponderosa* consociation with prairie remnants), and Canadian (Pseudotsuga-Larix mictium). The latter, which contains some 2-3% *Abies grandis,* is characteristic of the steep north slope. A few mature ponderosa pines are present near the upper limits. The Pinus consociation is confined to the ridge, to portions of draws of southern exposure and to a few benches low on the north slope. The prairie extends over most of the south slope and shows a variety of conditions: overgrazing, controlled grazing, shrub invasions, and a few small areas of nearly virgin cover. All stages of succession, from lithosere to climax, are found on the Butte.

2. TOTAL OF PLANTS REPRESENTED

Angiosperms:		160
Trees		1
Shrubs	Low	9
	High	7
Herbs	Annual	38
	Biennial	6
	Perennial	99
Gymnosperms:		4

Abies grandis. Lindl.
Larix occidentalis Nutt.
Pinus ponderosa Dougl.
Pseudotsuga taxifolia (Lamb) Britt.

Pteridophytes:	4
Bryophytes (Musci)	39

(Courtesy of G. N. Jones.)

*Contribution No. 42 from the Botany Department of the State College of Washington.

3. DOMINANTS AND PRINCIPAL SPECIES

a. Composition of the Argopyron-Festuca Association

Dominant Species

Agropyron spicatum *Festuca idahoensis*

Principal Species

Balsamorhiza sagittata	*Lupinus sericeus*
Festuca pacifica	*Poa ampla*
Geranium viscosissimum	*Poa Sandbergii*
Helianthella Douglassii	*Potentilla Blashkeana*
Hieracium Scouleri	*Rosa nutkana*
Lupinus ornatus	*Symphoricarpus racemosus*

b. Composition of the Poa-Antennaria Associes

Dominant Species

Antennaria dimorpha	*Poa Sandbergii*

Principal Species

Balsamorhiza sagittata	*Collinsia tenella*
Achillea millifolium	*Symphorocarpus racemosus*

c. Composition of the Pinus consociation

Dominant Species

Pinus ponderosa

Principal Species

Arnica cordifolia	*Spirea lucida*
Poa sandbergii	*Symphoricarpus racemosus*

d. Composition of The Pseudotsuga-Larix

Dominant Species

Larix occidentalis	*Pseudotsuga taxifolia*

Principal Species

Abies grandis	*Vaccinium caespitosum*
Opulaster pauciflorus	

AERIAL FACTORS

1. HUMIDITY

Records were taken at the same location for two years. During this time the extremes recorded were: high, 91% on November 6, 1931, and January 23, 1932; low, 3% on July 26, 1931. For the fall and winter months of 1932 the range fell most frequently between 50-60% with few fluctuations, and was considerably higher (on the average) than during the corresponding period of 1931. During the growing season the diurnal humidity range is most often from 25-40%.

The hours at which daily extremes are reached are in inverse relation to the times at which temperature extremes are reached. For example: During May in the Pinus consociation the humidity high is reached at 4-5 a. m. and the low at 4-5 p. m. The low is earlier for the Agropyron-Festuca association and later for the Pseudotsuga consociation.

Low humidity after about June 15 is of little consequence because by this time the earlier flora has matured, and the later plants are relatively drought resistant. As the season progresses the humudity tends to become rather uniform; however, during the growing season, there seems to be an increase in humidity as the climax is approached. The following

brief table suggests this situation:

Location	Humidity	Temp (F)	Wind Vel.
Pseudotsuga consociation	42%	52%	2-3 m.p.h.
Pinus consociation	35	54	18-20
Agropyron-Festuca association	33	58	20-25

Obviously air movement is important factor affecting the comparative humidity in a series of situations.

2. PRECIPITATION

Because of the impracticability of taking field records, official Pullman records for 1931 and 1932 were used. The rainfall at the two places is practically the same. For the years mentioned precipitation was 20.27 and 22.11 inches respectively, 20.73 inches being the normal amount.

The Seasonal distribution of rainfall is such as to produce an early flora, abundant in species and individuals, and to permit germination of seeds preceeding the fall snows. Plants appearing after mid-June are relatively few and capable of tolerating xeric conditions. Most of the winter precipitation is in the form of snow, and due to high winds from the southwest, large drifts accumulate on the lee side of the ridge. As a result the north slope soil receives more water than does the south but since this soil has a slightly higher wilting coefficient the actual difference in available water is modified. The flora in the area occupied by these drifts is retarded some 2 or 3 weeks for some species. Duff under snow cover makes for efficient percolation.

Summer rains are usually very light and of little value as a source of soil water. Due to dense tree crowns and undershrubs the north side soil may be barely moistened by such rains.

Duff is an important factor in limiting the amount of water entering the soil, decreasing the amount during light rains and increasing it during longer and harder showers.

The annual rainfall is sufficient to support a more luxuriant flora than now exists were it not for other factors, notably air movement and low relative humidity.

3. AIR MOVEMENT AND EVAPORATION

Prevailing winds are from the southwest, with an extreme velocity range of 1-70 miles per hour, the more frequent range being 10-30 m. p. h. Fall and spring winds may shift rapidly and be from almost any direction, least from the northeast. Southeast winds during these periods frequently bring rain or snow. Most chinook winds are from the southwest.

Quiet days are rare, occurring most often during periods of very low temperatures. Shorter quiet periods may precede a change in weather, and commonly there is a very brief daily lull in late afternoon and another in early morning.

Plants of the south slope are for most part exposed to the full effect of the wind; those on the north side are protected to such an extent that a 30-mile wind barely stirs the tree crowns, and is still further decreased among the undershrubs. Density of plant cover has an effect similar to that produced by slope exposure. Decreased air movement makes for higher relative humidity.

By mid-May an average wind velocity of 25 m. p. h. (relative humidity 15-40%) is rapidly removing the soil water, by transpiration and evaporation directly from the soil. By late June the available soil water is seriously reduced. The peak in evaporation rate is reached in late July, to be followed by a slightly lower one in mid-August. By the former date the more xerophytic plants are in flower. The less tolerant species have already matured, thus evading desication.

The possible evaporation rates in varied plant habitats are determined chiefly by air movement and humidity. The higher rates are found in exposed areas having a low or open plant cover, and the lower in protected areas having a denser cover. The evaporation rate decreases as the climax is approached; however, the condi-

tion should be considered chiefly as a result and not a prerequisite. For a given exposure the evaporation rate is much the same in shade as in sun.

Figures 1 and 2 indicate evaporation

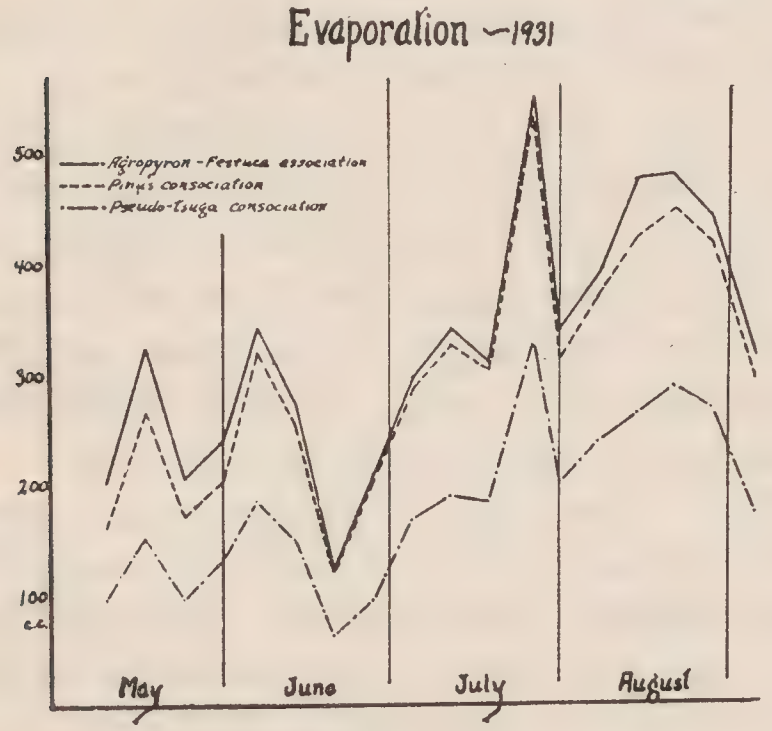

FIG. 1

rates in type covers, and indicate graphically some of the points mentioned above.

4. AIR TEMPERATURE

The most extreme range for an entire year was recorded for 1932 in the Agropyron-Festuca association: 5°-105° F. Due to cold air drainage and layering the lowest temperatures recorded on Kamiak are considerably above those recorded for the same period at lower elevations, eg. The coldest recorded on the Butte was 5° F. (elevation 3400 feet), while the lowest at Pullman was —25° F. (elevation 2300). Maximum high temperatures are much the same at all elevations studied. The following table gives a resume of the extremes.

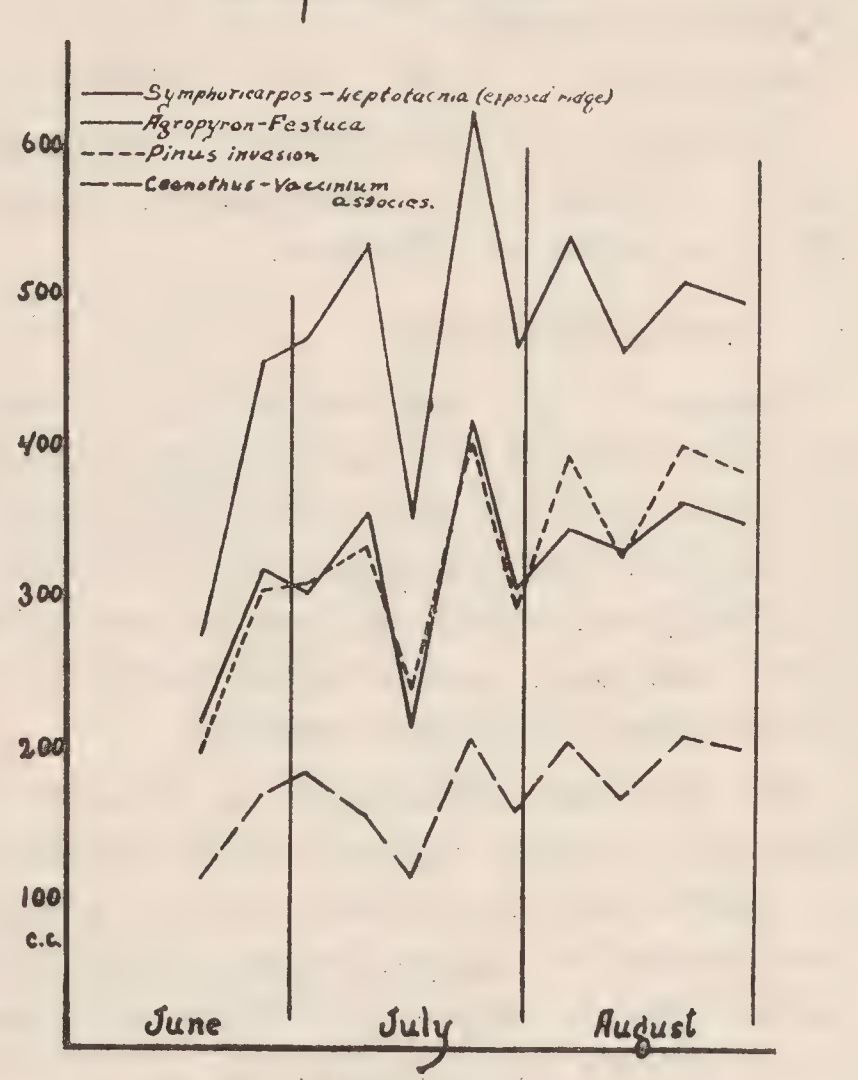

FIG. 2

Air Temperature

Location	Year	High	Low
Agropyron-Festuca association	1931	105 Aug. 21	8 Nov. 21
	1932	99 July 29	5 Feb. 6
Pinus consociation	1931	104 July 26	12 Nov. 28
	1932	101 July 2	9 Feb. 6
Pseudotsuga consociation	1931	100 July 26	9 Jan. 2
	1932	92 Aug. 13	11 Feb. 6

And a comparison of temperatures at other stations for time extremes were recorded at a given station:

	1931		1932	
High Location	July 26	Aug. 21	July 2	Aug. 13
Agropyron-Festuca association	102	105	97	97
Pinus consociation	104	97	101	100
Pseudotsuga consociation	100	93	83	92
Low	**Jan. 2**	**Nov. 21**	**Nov. 28**	**Feb. 6**
Agropyron-Festuca association	11	8	....	5
Pinus consociation	16	12	12	9
Pseudotsugaconsociation	9	17	....	11

Severe temperatures, within the extremes recorded, seem to be of slight importance in limiting plant activity, assuming the extremes to occur in season; however, the temperature factor as modified by air veolcity and humidity may, and does, have a profound effect on the vegetation, chiefly through excesisve desiccation. Seasonal extremes, unless lethal, are of less importance than the daily range during the growing season.

As a rule the temperature above the south slope shows a greater and more rapidly fluctuating range than that above the north slope. The following chart indicates the times of peak and low at different stations investigated, and also the lag in soil temperature.

	Peak		Low	
Location	Air	Soil	Air	Soil
Agropyron-Festuca association	1 P. M.	3-4 P. M.	5-6 A. M.	7-8 A. M.
Pinus consociation	3:30 P. M.		5-6 A. M.	
Pseudotsuga consociation	5 P. M.	7 P. M.	7-10 A. M.	9-10 A. M.

EDAPHIC FACTORS

1. GENERAL CHARACTERISTICS

Soils range from those composed largely of quartzite particles to extremely light ones. The latter are characteristic of the north slope and protected southerly draws. Much of this fine material has blown in, and accumulated in greatest quantity on the lee of ridges. Rapid accumulation and decomposition of plant debris results in protection of lighter soils, consequently the richer soils are found in protected areas.

The soil is rather superficial throughout, being deeper in general on the south slope and low north solpe. Borings deeper than 8 inches were almost impossible because of the presence of large rock fragments or the quartzite substratum itself. The steep part of the north slope is a rock slide covered by a very thin soil.

2. ORGANIC CONTENT

The organic content is in proportion to the amount of cover, especially when deciduous trees and shrubs. The following table indicates the incidental correlation between increasing organic content and progression toward the climax.

Festuca-Symphoricarpos associes	3.4%
Agropyron-Festuca association	4.0-5.3
Pinus consociation	4.4-5.5
Pinus-Prunus associes	8.8
Rosa-Spiraea-Symphoricarpos associes	8.0
Pseudotsuga consociation	7.8-13.0
Populus consocies	15.0-16.0

The effect of deciduous woody plants is apparent. The organic content of the soil in a given association cannot be used as an optimum content criterion for regeneration of species contained in the association, especially the dominants.

3. pH VALUES

Since there is an increase in acidity resulting from accumulation and decomposition of debris it follows that there will be an increase in pH values as the climax is approached. The fololwing sample records are arranged in successional sequence.

Agropyron-Festuca association	8.0*
Pinus consociation	6.76
Pinus-Pseudotsuga consocies	6.4
Pseudotsuga consociation	6.05
Pseudotsuga-Abies association	5.92

A five staged successional series following overgrazing showed a pH range of 6.53-6.8.

The increase of pH values is incidental to the successions investigated: no evidence was found to indicate that acidity within the limits measured, is a determining factor in succession.

4. WATER

Until mid-April the soil on both slopes is saturated. The water holding capacity of the north and south slope soils is ap-

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*(Seems too alkaline, but is the result of several readings.)

proximately 78 and 48% respectively. A rapid loss begins during May, and is partly replaced by infrequent rains.

Figure 3 indicates the progressive de-

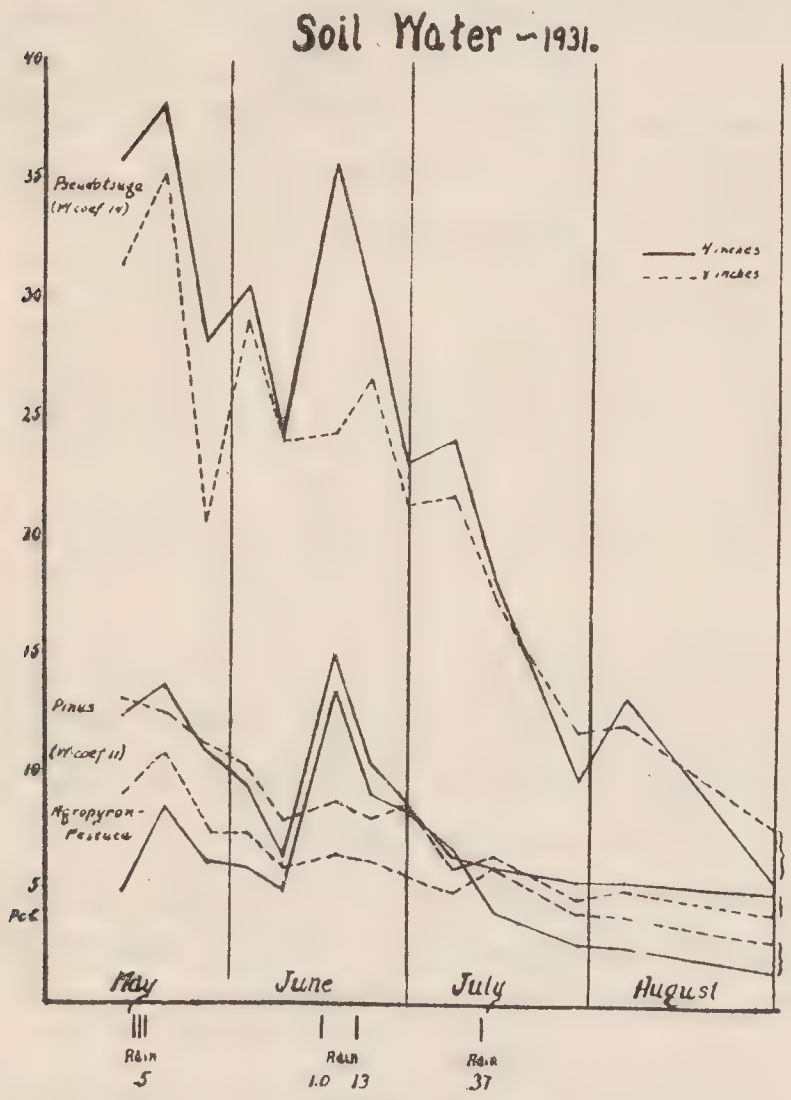

FIG. 3

crease in water content from May 13 to September 1. The effect of precipitation is also shown and is found to be negligible at 8 inches.

Loss of water is due to both transpiration and direct evaporation. Both factors operate vigorously on the south slope, but due to retarded air movement transpiration is the chief factor operating on the north slope and southerly draws.

The north slope olses the greater seasonal total. It also receives some water from fog condensing on, and dripping from, tree crowns and shrubs. Conditions on this exposure are more favorable to percolation than on the south slope.

Rapid desication of the surface soil layer soon creates conditions unfavorable to germination and seedling establishment. Since the dominants are mostly deep rooted species the records obtained are of little direct quantitative value, but they are suggestive of the probable root environment.

5. TEMPERATURE

All records were made at the 4-inch level. Seasonal extremes are much less than for the air, and increase directly with degree of exposure. Extremes recorded were:

Location	Year	High	Low
Agropyron-Festuca association	1931	72 Aug. 21	27 Jan. 2
	1932	69 July 2	31 Mar. 12
Pseudotsuga consociation	1931	68 Aug. 21	30 Feb. 21
	1932	68 Aug. 13	29 Feb. 6

Daily fluctuation is less than, and lags behind, that of the air. Sudden and pronounced air temperature changes, unless prolonged, are not reflected in the soil temperatures. The insulating value of 4 inches of soil is quite high, especially when other factors such as high water content, duff and snow are present.

The ground is usually covered with snow by the time frost has penetrated the upper few inches of soil. Once the snow cover is on a uniform temperature of 31-32° is maintained until spring thaws occur. During early February the snow on the south slope almost entirely disappears and the soil becomes sufficiently warmed to show a daily fluctuation in temperature. Due to direct exposure the soil warms very rapidly following snow removal, and the first flowers appear during early March. It is not until mid-March that the north slope soil warms sufficiently, due to percolating snow water, to show even a slight daily fluctuation. The daily range becomes more pronounced with loss of snow cover, but it is early May before a daily range of 3-4° is apparent.

Differences in soil warming in various exposures are reflected in the flora. eg. During the 1933 season Sisyrinchium inflatum was flowering on the south slope, by March 20, but not until May 25 were flowers produced in an area cooled by late

lying snow drifts. Effects of "late spring" are not reflected in the later flora.

During early spring and fall soil conditions on the ridge and south slope are favorable for germination and seedling establishment. Those produced in the fall have a better chance of survival (assuming normal snowfall) than those coming later in the spring, especially in the more exposed places. Rapid desiccation and high temperatures resulting in the upper 3 inches of soil, following high winds and bright days, are very unfavorable to very young seedlings. Those starting in the fall are likely to have developed a root system sufficiently extensive to withstand surface desiccation. Seedlings are fewer on the north slope, but the limiting factors are not those just mentioned.

LIGHT INTENSITY

All light determinations were made in terms of candle power. Since even the diffuse light under plant cover is essentially white the readings should bear a meaningful comparative relationship.

Determinations were made at different times of day and season. There seems to be little difference, just so long as they are taken between 10 a. m. and 2 p. m.

Situations were chosen on the basis of value as types or for their relation to a specific succession. All readings vary considerably unless made in uniform light or shade. The record listed below was made June 22 between 11:30 and 12:30. Only a few typical items are listed.

Direct light	15,000 c.p.
Cover of Pinus, uniform shade	700 to 900
Cover of Pinus, splotchy shade	3,000 to 4,000
Cover of Pseudotsuga, deep shade	75 to 80
Cover of Pseudotsuga and Opulaster (under latter)	20
Cover of Agropyron, splotchy shade	4,000 to 7,000
Cover of Rosa-Spiraea-Symphoricarpos	2,000 to 3,000

(Very active Pinus invasion.)

Presence of passing clouds cuts light value to about 20%.

A slight shade results in decreasing the soil temperature as much as 40% at a depth of ½-inch.

Under field conditions it is probable that a great deal of the so-called "light tolerance" is really a reflection of edaphic conditions.

No *Pinus ponderosa* seedlings were found in situations with a light value of less than 600 c. p. *Pseudotsuga* was found to be quite tolerant of light as such, but decidedly limited by such attendant factors as soil temperature and water.

BIOTIC FACTORS

Miscellaneous field records of the fauna were made over a 3-year period, with an intensive trapping campaign in the spring of 1931. Species listed are:

Coyote	*Canis spp.*
Columbian ground squirrel	*Citellus columbianus columbianus*
Porcupine	*Erethizon epixanthum epixanthum*
Chipmunk	*Eutamias amoenus amoenus*
Marmot	*Marmota spp.*
Meadow mouse	*Microtus mordax mordax*
Weasel	*Mustella spp.*
Wood rat	*Neotoma cinera occidentalis*
White footed mouse	*Peromyscus maniculatus artemisiae*
Pine squirrel	*Sciurus hudsonicus richardsoni*
Cottontail	*Sylvilagus nuttalli nuttalli*

All except two species seem to be neutral (normal pressure). Citellus — very abundant and extending its range. Actual feeding habits of little ecological impor-

tance. Their habits of developing extensive systems of well-packed trails and bringing up great quantities of sub-soil during their burrowing activities are of great importance inasmuch as that in either case there are produced focal points for the invasion by such weeds as *Sisymbrium, Bromus tectorum.* The habit of piling gemules at the burrow entrance speeds up both weed and shrub (*Symphoricarpos racemosus, Prunus demissa*) invasion.

Erethizon—apparently numerous, with general range. Feeding habits very detrimental to tree cover: as high as 60% of the trees surrounding a rock slide containing dens have been killed. Of the trees attacked the percentage runs about as follows: Pinus 75%, Pseudotsuga 20%, Larix 5%. A shrub sub-sere is rapidly developing.

GRAZING EFFECTS

Most of the prairie areas have been extensively grazed. One area which had been closed for 4 years was opened in the spring of 1933. In 2 weeks practically all the *Festuca* was clipped to near ground level and the *Agropyron* topped. *Leptotaenia* and *Balsamorhiza* also suffered severely. After a month this area was closed again, and by July the grasses mentioned above had developed vigorous, but less abundant, tops. Under conditions of proper management this area could be cropped twice annually, or opened continuously to a small herd.

Shurbs, notably *Prunus demissa, Symphoricarpos racemosus* and *Berberi repens,* invade rapidly following severe grazing. *Bromus tectorum, Antennaria dimorpha* and *Leptotaenia* (especially when abundant) are also common indicators of disturbed prairie, and are taken to some extent by stock. *Poa Sandbergii,* a secondary species in the prairie association, persists following even very severe grazing: in fact it frequently becomes a dominant in the early stages of succession following overgrazing.

A direct comparison of results from controlled and uncontrolled grazing is shown in one place where a fence crosses a prairie strip. On one side is a Leptotaenia-Symphoricarpos associes and on the other a luxuriant Agropyron-Balsamorhiza association (containing some Festuca). The former cover is almost valueless as such, but suggests a possible invasion by ponderosa pine. In either case its value as grazing land is almost nil.

None of the overgrazed areas are returning to their original cover, but instead are rapidly being invaded with those shrubs which typically precede a *Pinus ponderosa* invasion.

SUCCESSION IN UNCULTIVATED FIELDS

On the south slope are three fields which have not been cultivated for from 3-7 years. Although the successions are in different stages, depending upon the age, the same general sequence is common to all three. Consequently only a summary will be given.

Such weeds as *Sisymbrium altissimum, Verbascum thapsus, Bromus tectorum, Epilobium adenocaulon,* and *Cirsium lanceolatum* are common first invaders and may come in as scattered individuals or as invading consocies. Scattered individuals of *Rosa nutkana* are usually present, with *Prunus demissa* and *Symphoricarpos racemosus* invading marginally in dense stands. These shrubs are frequently followed by *Populus tremuloides,* especially in protected locations, which is in turn followed by *Pinus ponderosa.* Or the Pinus may come in directly with, or following, the shrubs. Fence rows frequently develop dense stands of *Rosa nutkana* and *Symphoricarpos.*

There is no evidence of a return to grass land. Instead it seems that the trend is toward a Pinus consociation.

GENERAL TRENDS OF SUCCESSION

Figure 4 indicates graphically, and rather completely, this phase of the situation.

TRENDS of SUCCESSION

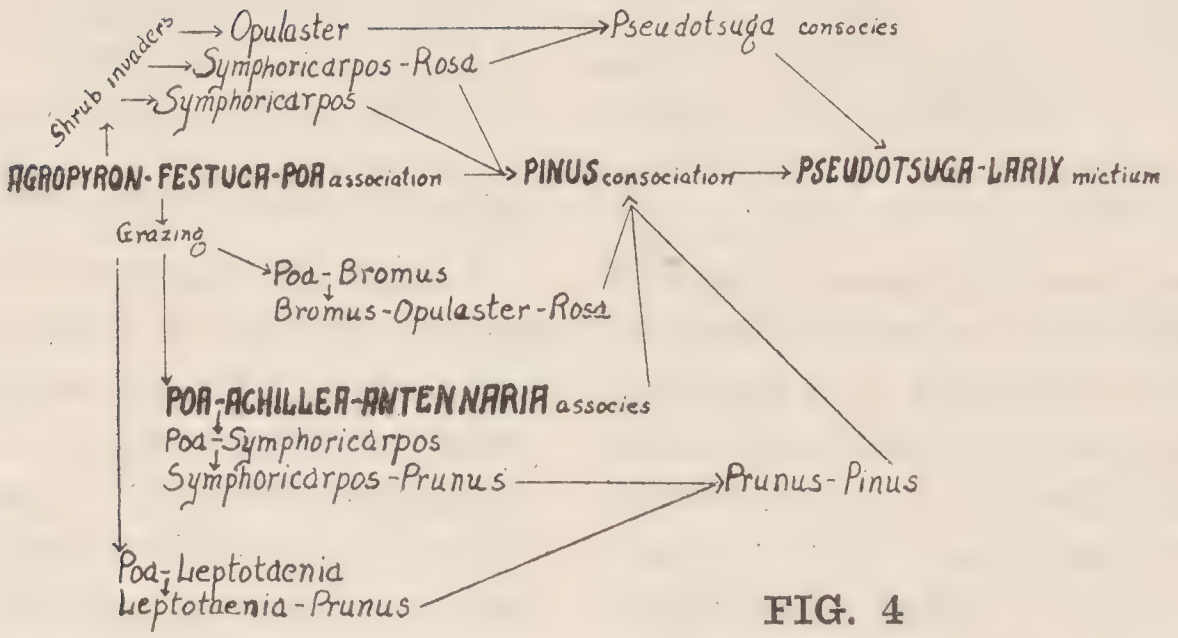

FIG. 4

SUMMARY

The evidence is that at one time Kamiak was covered by prairie vegetation, and that the essential steps in the succession to the tree cilmax, on the north slope, are still represented on the ridge and south slope. The trend on the south slope is toward a tree cover. The climax, however, will be different from that for southerly draws and the protected north slope. A *Pinus donderosa* savannah seems the probable climax, with a Pinus-Pseudotsuga mictium in the draws. The north slope seems well adapted to regeneration of the Pseudotsuga-Abies climax. (The area was heavily logged about 1885.)

As the climax is approached certain environmental factors are altered.

EDAPHIC
a—increase in organic content.
b—increase in pH values (alkalinity).
c—increase in water holding capacity and wilting coefficient.
e—more uniform temperatures.

CLIMATIC
a—decreased air movement.
b—decreased rate of evaporation.
c—decreased light values.

VEGETATIONAL
a—tendency toward pronounced layering.
b—production of conifer tree dominants.
c—decrease in number of plant species.

The evidence is that whenever the prairie is disturbed a succession, tending toward a *Pinus ponderosa* climax, is begun. There is no evidence of a return to prairie conditions.

The prairie grasses most persistent following *Pinus* invasion are *Festuca* and *Poa*; and the shrubs, *Symphoricarpos* and *Spiraea* Seedlings of both *Pseudotsuga* and *Pinus* are light tolerant, but those of *Pinus* are better able to withstand the resultant heat and soil desiccation.

Summer meeting of the American Association for Advancement of Science in 1940 is tentatively scheduled for Vancouver, B. C.

Dr. David L. Soltau (B. S., A. M., Northwestern; Ph. D., Washington) has accepted the Presidency of the Longview Junior College. Dr. Soltau, who for several years held the chair of Physics at Whitworth College, has had a colorful life. Born in Launceton, Tasmania, taught Physics for a time in Union Christian College, Pyengyang, Korea, where he also was school principal and architect and consulting engineer for missions.

Exotic Ancient Forests of Washington

By GEORGE F. BECK

From the University of Washington FOREST CLUB QUARTERLY, Spring 1936. Because of the wide interest of the matters treated in this paper a rule which has been quite uniformly followed by NORTHWEST SCIENCE is broken in printing an article which has appeared in another publication. Another article from Mr. Beck dealing with his work on the paleontology of Central Washington is promised for either the November or the December issue.—Editor's Note.

Five years ago we began our study of the Ginkgo Petrified Forest in Central Washington. This in reality is a series of forests occurring at various horizons in the Yakima (and Wenas?) basalts throughout a vertical range of some two thousand feet, and in a belt 150 miles long and 50 miles wide centering at Vantage on the Columbia River. Here a particular horizon 800 feet more or less down in the Yakima basalts and extending over an area six miles in diameter serves as the type forest for our study. While this particular horizon has received the greater part of our attention, the other forests and horizons have not been neglected. This type forest is called the Vantage Forest, and the pillow lavas in which the logs have been buried together with the underlying sediments are here designated Lake Vantage. Hereafter the term Ginkgo Forest will be understood to relate to the whole series, and the Vantage Forest restricted to the one horizon or episode in the series. The whole group is understood to be Upper Miocene in age.

What first impresses one as remarkable in this series of forests is the abundance of tree and forest types and the difficulty of association either of these with the present trees and forests of Washington. David Douglas, pioneer naturalist of the Pacific Northwest, encountered what he recognized as petrified trees at Bonneville 110 years ago and conservatively assumed them to be a conifer and hardwood derived from the existing forests. I. C. Russell, in a geological reconnaissance of forty-five years ago, noted the prevalence of petrified trees in Central Washington, and after having sections made announced the discovery of pine and oak.

When I began my study of the petrified forests of Central Washington I was not acquainted with the published work of either of these men, but like them, I assumed that just a few types closely related to our present Washington trees were all that was involved. To my consternation it soon became apparent that an intimate acquaintance with the forest trees of the whole of temperate North America was necessary to any understanding of these ancient forests, and that a hardly less intimate knowledge of the forests and trees of the whole northern hemisphere would be required for the final interpretation of all the materials collected.

Fossil leaves of an equivalent late Tertiary Age had long been known to paleobotanical authorities and two schools of opinion and thought had arisen. Those who have had under examination the Miocene leaves of Central Oregon and southward have been inclined to interpret these ancient forests as fundamentally redwood in character, that is, with the trees of the modern redwood forests already in a dominant role. Those who have worked with the Miocene leaves of Eastern Washington have seen in them the forests of the eastern United States with the trees of the Atlantic seaboard in the position of dominance. In both the north and south divisions of this great Inland Basin there has been recognized a more or less conspicuous Asiatic representation. We shall call these respectively the California, the Atlantic, and the Asiatic elements of these old forests with which we are concerned. Naturally the reader will be as anxious as was I to see to what extent the petrifed forests reflect any or all of these elements.

We began collecting with the precon-

ceived opinion that if the petrified trees were not Washington in character they would at least carry a dominant California element. When we could find no conspicuous Washington element we began in earnest to search for Unbellularia, Torreya, Castanopsis, live oak, and such redwood border trees as Aesculus. These have persistently refused to appear and to our embarrassment the genera recognized impress one with their suggestion of Eastern American types. Turning to the list of Miocene leaves which had been interpreted as Eastern in character, we were at once challenged to account for the failure of such genera at Castanea, Liriodendron, Magnolia, Salix, Tilia, Aesculus, Alnus, Carpinus, Ostrya, etc., to appear among the woods. Practically all of the genera above listed have been recognized in the Miocene leaf beds.

After five years of field work and the examination of specimens which must represent thousands of individual trees and dozens of forests, we have come to the conclusion that we can reconcile the wood lists with those of the two diverse leaf lists and the two latter with each other. This is offered merely as a hypothesis upon which future field work and laboratory study will be based under the assumption that a year or two of work will prove or disprove the theory. Whatever checking we have done in the few months since the hypothesis came to mind has tended strongly to increase our faith in the following solution of the problem.

Our first step was to grant that the trees and forests which grew on the succeeding lava flows were likely to contrast in character with those which grew on the surrounding uplands serving as the catch-basin walls into which the lavas had been poured. It was conceivable that the proportion of leaves from these two contrasting areas would differ from the proportion of logs derived from the same areas. We assumed that each lava surface would present such little contrast in slope, soil, moisture, etc., that the forest which it bore would be practically uniform excepting as the various stages of a single sere (xerosere?) might be represented. This was a step in the right direction but not far enough. Through the work of Dr. Fuller of the University of Washington, we became conscious of the prevalence of pillow lavas in the basalts of Central Washington, and as a result it has become apparent that our various forests consistently, if not exclusively, occur in pillow zones. This means that the logs preserved were associated with standing water at the time that the lava overwhelmed them.

We had already recognized two extremes among the forest types. One dominantly Sequoian (Taxodium and, or Sequoia—a redwood forest?), and the other largely Picean (spruce, and, or tamarack—the Atlantic forest?) with of course a great many hardwood trees, mostly in forests of a transitional character. It was hardly possible that such a variety of trees (75 or more genera) could have grown originally within the few square miles in which they are now found as fossils, and in fact, many of the logs are prostrate and devoid of bark as though rafted in from a considerable distance. This feature led to the conclusion that many of the trees must be "extra-lava," by which we mean that they must be foreign to the lava in which they are now found and may have been rooted miles away in a strongly contrasted habitat.

Pursuing the study along this line it became apparent that the Sequoian forests are those which were rooted and buried in situ, and that the Picean forests are in all cases prostrate logs, members of rafts which may come from an indefinite distance. Later we became convinced that many of the Sequoian trees are in fact Taxodium and we began to visualize upon the succeeding lava flows wide-spread swamp forests such as may today be found in the Dismal Swamp area of the Atlantic seaboard. Associated with the Swamp Cypress occur those trees which one would

expect in a swamp area of varying depth and acid content: white cedar, water ash, tupelo, dogwood, etc., and there are missing those trees which one would be surprised to find in such a situation. In support of the swamp idea is the presence of what apparently is petrified peat and swamp bottom. On the other hand, spruce, tamarack, elm, walnut, etc., are yet to be recognized as rooted on any lava surface and the conviction grows that they grew upon some surrounding extra-lava lowland or upland. Carrying on the idea, it is quite conceivable that cchestnut, tulip tree, magnolia, alder, willow, etc., whose presence has been indicated by leaves but whose logs are so far entirely wanting, may have grown upon uplands and divides where their logs were not accessible to streams large enough to carry them into the basin. It is entirely reasonable that the present day Pacific Coast and Washington forests existed on high, dry uplands or in other situations in which the opportunity for preservation of both leaves and logs was not favorable. We are quite convinced that present day generic types and their habitat preferences have remained fundamentally the same since the Miocene. Probably all units of the temperate North American forests were found somewhere in suitable locations in the inland basin of Washington during the Miocene and that among these familiar and dominant American trees there were a great many exotic species in a sub-dominant role.

BOARD OF TRUSTEES

At a meeting in May a reorganization of the Board of Trustees of Northwest Scientific Association placed E. M. Keyser, of the Spokane Weather Bureau, in the Chairmanship, replacing Mr. Weidmann, resigned. The meeting authorized the publication of the booklet on the aim and methods of work of the Northwest Scientific Association Corporation which had been prepared by Mr. Keyser. The Association at its General Meeting in 1932 adopted constitutional amendments designed to make an effective part of the Association the legal corporation which had been formed in 1928. One of the provisions of these amendments was for a large Board of Trustees with a small Executive Committee, hoping by the combination to secure the wisdom of many with the effectiveness of action of the few. Messrs. Keyser, Judd and Neustell compose the Executive Committee. At this meeting Flint Memorial Fund was formally adopted as one of the projects of the Association for financing research. Mr. T. H. Judd of Spokane is General Chairman of this fund for the Executive Committee, with Major Kelly as his special assistant.

SUBSCRIPTIONS already secured to the Howard Flint Memorial Fund indicate that this may be an important aid to scientific research. Already several hundred dollars have been received. Major Evan A. Kelly, Regional Forester, Missoula, Montana, and Mr. Judd will continue to receive contributions or subscriptions.

It may interest readers to know that there is a demand for complete files of Northwest Science. Persons having extra copies or back files which they do not wish to keep for their own use may find it to their interest to write the Secretary of Northwest Scientific Association, Dr. O. W. Freeman, of Cheney, Washington.

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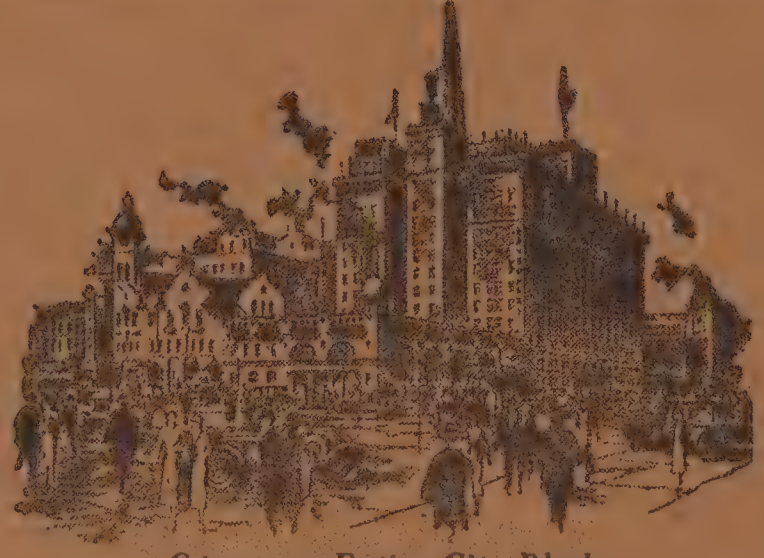

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NOVEMBER, 1936

Vol. X No. 4

Published by

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Single Copies Thirty-five Cents

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-:- NORTHWEST SCIENCE -:-

A journal devoted to the dissemination of scientific knowledge and encouragement of research in the Pacific Northwest

TO BE PUBLISHED IN FIVE NUMBERS IN 1936

BY

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Entered as Second Class Matter, April 5, 1927, at the Postoffice at Cheney, Washington. Office of Publication, Cheney, Washington. Subscription Price to Members, Including Dues, One Dollar per Year; to Non-Members, One Dollar.
Volumes I. to IX., 1927 to 1935, Each $1.25

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NORTHWEST SCIENCE

VOL. X. NOVEMBER, 1936 NO. 4

The Association is not responsible, as a body, for the facts and opinions advanced in the papers published by it.

What Causes Our Floods?

By W. A. ROCKIE

Regional Conservator, U. S. Department of Agriculture Soil Conservation Service

Spokane, Washington

Flood control has, in recent years, become a term so shopworn that a clearer understanding is needed. During the two years that have just passed many of the towns, communities, counties, states and regions over the entire country have developed hundreds and probably thousands of detailed plans for "flood control," as it has generally been termed. While millions of dollars of public funds, community, county, state and federal, have been spent during this period on these many "flood control" projects, very little of the money expended has accomplished "flood control." The aim of these projects has usually been "flood diversion" rather than "flood control." Very few of them were planned to control the floods.

There is only one way to control a flood and that is to prevent the accumulation of sufficient uncontrolled water to cause that flood. In other words, the water must be prevented from "piling up" at any given point in dangerous quantities.

A recent personal experience illustrates how nature controls, and how she causes, floods. While traveling eastward across Iowa by plane on October 20, 1934, a bank of heavy clouds was observed far to the eastward after taking off at Council Bluffs, Iowa. An hour later upon leaving Des Moines the storm had begun to loom up more noticeably and each of the passengers took increasing interest in the dark and ominous bank of clouds. Evidence that a considerable rain was ahead of the ship showed in the water-logged soil of every field and the plant cover glistening brilliantly in the reflected sunlight. After the plane passed Iowa City the very heavy character of the rain became more and more noticeable.

The plane was flying at a rather low altitude, at no time exceeding five hundred feet above the land. For this reason every detail of all ground activities was readily seen and could be studied.

This section of Iowa shows intermingled fields of woodland, hayland, newly germinated winter wheat, bare land and cornfields as well as numerous other types of vegetation that could not be so readily identified from the air.

As we traveled eastward the after effects of the rain became more evident. Directly north of Davenport, Iowa, we looked down on streams that were mostly either flush with the banks or overflowing with a buff-colored or yellowish-brown fluid mass. The run-off from these hills had already ceased. From this point eastward, however, the changes were so rapid and so kaleidoscopic that there was displayed a veritable moving picture of changing conditions in reverse order.

Still farther eastward the yellowish rivulets flowed from every bare field in limitless numbers while the plant-covered fields showed no evidence whatever of material run-off. These rivulets as we passed eastward kept creeping farther and farther up the slopes. The stage of the

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flood in the drainageways became less and less advanced, until as we entered the rear side of this storm the stream courses showed that no flood situation had yet developed in that area, while the ridges and slopes were literally plastered with fluid threads of this yellowish-brown run-off wherever they were not adequately protected by vegetation. These hundreds of rivulets were gathering as rapidly as slope and cover would permit into larger and ever larger streams.

Broad, gently sloping uplands, having no cover, shed off large quantities of this soil-laden fluid, and, unless a lower slope having adequate plant cover intervened to absorb this water and to strain out and deposit the soil, it was dumped into the nearest drainage course. This observation was repeated on hundreds of different fields as we traveled directly behind, and heading into, this storm. While its violence and severity were being observed at close hand, however, the plane turned to the northward. The pilot chose to avoid the center of the storm and followed for many miles northward along its rear edge in an attempt to find a hole through and thus to reach its eastern border. During all of this progress northward, the plane flew in the tail end of a heavy shower where floods were in the making below us, where individual casualties of the storm in the way of scampering poultry and pigs, implements, vehicles and other things left in the flood's path, demolished fences and other property of the various farm owners, were passing in continuous review.

While the run-off was at its height from the fields and before it had gathered to form larger floods, men, women and children were observed running about, rescuing articles that had been thoughtlessly left outdoors. They were intent on accomplishing some particular task made necessary by the sudden avalanche of water from the sky.

All the time we were in the tail end of this storm, floods on the drainageways had not yet formed although the ridges and slopes were covered with yellowish-brown rivulets, each of these contributing its small part to make up the flood that was to follow.

A barn lot of approximately one acre having no protective plant cover was seen as an island within surrounding fields of hay and other cover crops. From this barren lot dozens of yellow streams of mud were spreading down into the hay fields on the lower side. These rivulets of soil-water mixture were able to progress only a few feet into the plant-covered land until they were completely absorbed into the soil.

After searching the western wall of the storm for a long stretch of miles northward to find a break, the plane circled about and started southwestward toward Iowa City.

After the plane was turned back to the westward we rapidly passed through the zones of: 1. run-off before the floods had time to form; 2. floods after the run-off had gathered into the drainage courses; and 3. the same water courses after the subsidence of this sudden run-off.

The dendritic or tree-shaped pattern of drainage that is universal in this region is very apparent from an air view and it was therefore easy to study the conditions affecting watershed or drainage units. On this return trip away from the storm, it was striking to note that those few drainages which had a heavy plant cover over most of their area showed practically no flood conditions, while those that were dominantly unprotected land showed peak flood conditions. This condition was observed on several drainages.

Such a view of an intense rainstorm and the irrefutable evidence that was seen during this very brief flight over the area of the heavy rain gave convincing evidence and proof that plant cover is absolutely necessary on a much larger proportion of the land area of this country than it now covers. This must be accomplished if our civilization is to remain.

The entire incident happened within an

hour, with all stages of the formation of floods presented in moving pictures, first seen in reverse as the storm was approached from the rear, and as the plane returned westward for a temporary landing place, seen in proper sequence from start to finish.

This interesting aerial observation fascinated the passengers and caused detailed comment. The generalized thought of the different individuals was, "This was the first time they had ever seen a flood develop in a way that showed the causes of its development."

This was not a big flood nor was it an important incident, but it showed clearly how and why floods form. Every bare field was utterly unable to absorb the water as it came down, while all lands supporting a heavy plant cover showed no serious water run-off. The water from these plant-covered areas was not of sufficient quantity to cause the immediate flood conditions that were so common below the bare fields.

This portion of Iowa is mostly covered by a glacial, and, adjoining the breaks near the Mississippi River, a loessial mantle. These wet soils as they appear from the air are very dark brown to black in color and the striking contrast afforded by these yellowish-brown rivulets flowing on this dark land surface gives concrete evidence that a considerable portion of the topsoil from this land has already been washed away and that the present washing is well into the yellowish subsoil beneath.

An air flight across Iowa on a clear day gives unmistakable evidence that such storms have come hundreds of times and the lesson that was indicated by the vegetated and the non-vegetated fields showed that erosion can be minimized by a more generous plant cover on our land.

Up to about twenty years ago practically no authoritative information was available in the United States as to the effect of plant cover on the use of water. About 1914 and 1915 some individual efforts by personnel of several federal and state agencies toward obtaining authentic information along this line were initiated.[1] Not until 1928, however, were definitely coordinated and correlated measurements taken in various parts of the country. At this time a Congressional appropriation for establishment of several soil erosion experiment stations was initiated. These funds were made for the use of the Bureau of Chemistry and Soils with the cooperation of such other agencies as it was decided to include. Immediately thereafter and during the succeeding two years, a number of such experimental areas were established. These funds were being expended directly by the Bureau of Chemistry and Soils, the Bureau of Agricultural Engineering and the Forest Service. By the year 1932, the facts that were positively known as a result of these experiments were so conclusive and so overwhelming in their meanings that there could be but one interpretation.

The results from all of these stations and experiments showed conclusively that our soil and water losses could be really controlled in only one way, namely, by an adequate use of sufficiently heavy growing plant cover to accomplish ready absorption of most of the precipitation. From every point of comparison came the information that grass cover and forest cover were both practically 100 per cent successful in preventing soil and water losses. All other controls ran a poor second when used alone, but when used in conjunction with vegetation, made partial plant cover more effective. The heaviest cloudbursts falling on grass-covered land were practically all entirely absorbed, while the same rain on adjoining unprotected land caused enormous losses of both soil and water. The details of these experiments that were performed on all types of lands in all types of climate in many parts of the country by different federal and state agencies combined to give just one result—name-

ly, proof that soil and water conservation was possible and feasible provided the right measures were taken.

Concrete examples have occurred during the past year at many points in the United States which have proved on a much larger scale that the facts brought out by these experiments are fundamentally sound. Possibly the most striking of all these facts is the case of the New Year's flood at Montrose, California, during the winter of 1933-34.[2] Here were two small-sized drainage areas that sixty days before had been almost identical. One of these had, however, in November, 1933, been burned over and the plant cover almost entirely destroyed. The soil was left exposed and unprotected, while on the adjoining drainage area the original conditions remained. With the advent of heavy rains in late December on these lands, the effects of this change on one of these areas was at once made evident. The unburned drainage area absorbed practically all of a rainfall that amounted to about 9 inches of water in 36 hours, while in the adjoining burned area of equal size where the rainfall was almost identical, the worst floods in the history of the community were experienced. Many lives were lost in this flood. The soil and water losses were terrible and the resultant damage was concrete proof that vegetation must be kept covering more of our lands if these lands are to remain an asset to the country.

If floods are to be controlled, we must first recognize the causes of floods. We must deal with the causes if we desire to eliminate those floods. Most of the flood control efforts of the past have had the "cart before the horse" because they have not had in mind the prevention of floods.

Our viewpoint should be redirected toward the causes and, finally, our efforts must result in the elimination, or at least, a minimization of these causes.

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Bacterial Flora in Skimmilk Powders[1]

By W. V. HALVERSON and FRANK MLEYNEK

The use of milk powders is increasing so that at the present time the ice cream industry, the baking industry and general household uses are employing them on an equal basis with canned milk and fresh milk which has been produced under very strict dairy regulations. Some of the apparent advantages of using a desiccated milk product are convenience, uniformity of the product, freedom from spoilage, less bulk and high nutritive value.

A study of the methods of manufacturing milk powders reveals the fact that fundamentally three processes are commonly used, namely, the Just-Hatmaker roller process, the Gray-Jensen spray process, and the Passburg vacuum drum process. However, powders are being manufactured by various modifications of each of these basic processes. Each of these processes uses temperatures far above the thermal death points of pathogenic organisms which might ordinarily be encountered in milk. The Just-Hatmaker process employs a temperature on the heating surface of the cylinders not below 212° F. and not above 270° F. The Gray-Jensen spray process employs a preheating of the milk at 170° F. in the tank, a concentration at 122° F., and a final heating to 165° F., when it is sprayed into a drying chamber containing air at about 260° F.

The vacuum roller-Passburg process employs a temperature in the vacuum chamber during drying of from 104° F. to 131° F., depending on the completeness of the vacuum obtained.

Thirty samples of milk powder have been studied, as follows: 13 prepared by the spray process, 8 by the vacuum process, and 9 by the roller process. This small number of samples cannot be considered adequate to draw authoritative conclusions but they do point out some interesting things.

1. Molds were found in practically all samples, the number varying from 0-30 per cc. of 10% milk solution. The most common molds observed were *Penicillium, Aspergillis* and *Rhizopus*

2. Yeasts were found in only two of the thirty samples.

3. Acid-forming bacteria were present in all but two samples. The count varied between 0 and 82,000 per cc. of 10% milk solution on lactose-lime-agar, whereas strong acid formers varied from 0-397,000, and weak acid formers between 0 and 511,900 on nutritive caseinate agar. Total bacteria varied between 3,000 and 401,000 per cc. on a standard nutrient agar. Peptonizing bacteria varied between 0 and 9,000 per cc. *Escherichia coli* was definitely isolated from three samples of milk.

4. The H-ion concentration varied between pH 6.3 and 6.7.

5. The moisture varied from 2.20 to 6.4%.

6. Generally the larger numbers of bacteria were encountered in samples which had been prepared most recently.

[1] Presented before Section of Bacteria and Public Health, Northwest Scientific Association, December 28, 1935.

Ground Subsidence at Bellingham Coal Mine*

By C. S. FREDRIKSEN

INTRODUCTION

This paper reports an examination to determine the cause of ground subsidence in the Cornwall addition to the city of Bellingham, which overlies a portion of the mining operation of the Bellingham coal mine. The problem was also extended to determine a method which would eliminate the possibility of future subsidence in Cornwall addition, the only residential section overlying the mining operation.

SUBSIDENCE AREA

The surface of the ground had subsided about 18 inches over an elliptical area roughly 320 x 325 feet, where several dwellings were affected so far as their foundations, plaster and chimneys were concerned.

DEPOSITION OF SAND AND GRAVEL

The area in and around Bellingham is covered by glacial drift that was deposited by the large ice sheet known as the Puget Sound Glacier.

This great ice sheet advanced from the north, planed down and rounded off the shales and sandstones that compose the Eocene coal measures. When this ice sheet retreated, it deposited its vast load of rocks, sand and fine sand, known as rock flour, and gravel that it had accumulated. This was deposited in a horizontal position in an unsorted manner typical of glaciers.

As the ice sheet continued to retreat, the upper portion of this deposit was roughly re-sorted by stream action, which resulted in the layers of gravel, clay, fine sand, clay and gravel. The upper gravels also contain a large amount of very fine sand.

UNDERGROUND MINE WORKINGS

The mine workings, adjacent to the area in question, is roughly 496 feet below the surface. A vertical cross-section from the coal seam to the surface taken from a bore hole log shows the following formations: 20 feet of shale, a few feet of fire clay; 120 feet of sandstone and the remaining distance are layers of sandy clay, rocks and boulders; sandy gravel; clay;

fine floating sand; clay; and gravel.

The pillars of coal left in the workings for support were found intact and in no instance was there any evidence of unusual pressure of the overlying beds, or any indication that the overlying shale or sandstone had fractured. If such were the case, the mine would have been flooded, causing an acute mining problem, or at least continual pumping would be necessary. On the other hand, the mine at this point, as well as throughout the entire workings, is dry, except for the strata of fine floating sand near the surface, at this point pumping is necessary.

The conclusion was that the mining operation, in no way, have been responsible for the subsidence in Cornwall Addition.

CAUSE OF THE SUBSIDENCE

The area in question is traversed by Squalicum Creek, a meandering stream that has lowered its channel 35 feet into the gravel and a short distance into the underlying clay stratum. This stream parallels the subsidence area on the west.

At the contact between the clay and gravel is a permanent water-course, and springs are numerous along the banks of the stream. Under ordinary conditions this drainage is sufficient to accommodate normal flow, but in the fall and in the spring when conditions are abnormal, this water-course cannot take care of the added volume, and the water rises (up) through the gravel and floods the basements of the dwellings.

The gravel being a typical "glacial drift," also contains a large amount of very fine sand or "rock flour," a quicksand when deposited as such.

As the water rises through the gravel the fine sands drop and such is the condition when the water recedes, exhausting this fine sand, carrying away a certain amount on the clay water-course and depositing at the vents of the springs that are numerous along that side of the creek.

This action continuing over a period, exhausted the fine sand to such an extent that the ground had settled noticeably where is the added weight of dwellings, and along Maplewood Avenue where there is heavy traffic, especially of large trucks.

EXPERIMENT WITH MODELS

To verify the above conclusion several models were constructed, paralleling surface conditions in every way and the results of these experiments proved conclusively that the subsidence was caused by the exhaustion of the fine sand from the gravel.

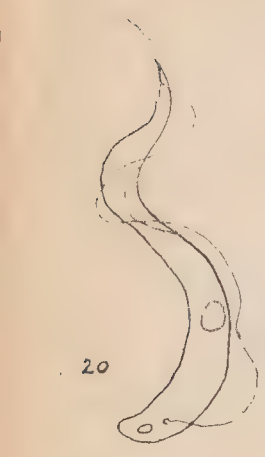
PREVENTION OF RECURRENCE OF SUBSIDENCE

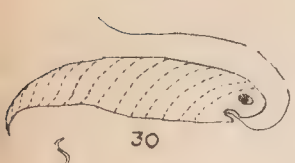
Determining what caused the settling was comparatively simple, but to devise a reasonably economical remedy which would drain off abnormal flow and eliminate the possibility of future subsidence in Cornwall Addition proved to be the real problem.

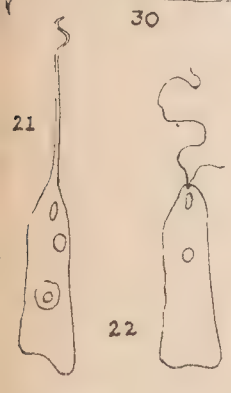
A study of the surrounding district disclosed the presence of a synclinal basin where the clay stratum contacted the steeply dipping sandstones as exposed adjacent to the effected area, which served as a natural catch basin. The construction of a trench eight feet below the surface and properly cemented or tiled draining off the flow at this point along the boundary line of the district and cleaning out the sediment in Squalicum Creek thus lowering the stream bed will eliminate the possibility of a recurrence of any future subsidence in Cornwall Addition.

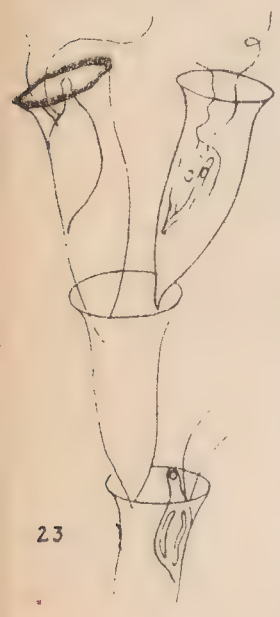
I might state in closing that the drainage ditch would parallel Cornwall Park and a road, and being only eight feet below the surface where no dwellings will be built, a subsidence along the line of the drain would be so slight that it need not be considered.

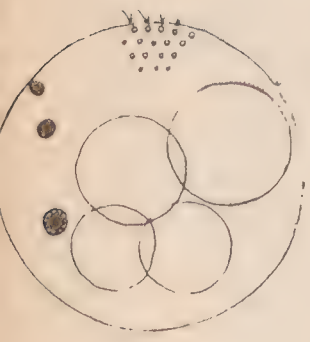
*Delivered before the Northwest Scientific Association, Geology and Geography Section, December 27, 1935.











The Importance of the Protozoa and My Observations of Them

By RALPH LAWRENCE

This essay was given third rank in the National Scientific Essay Contest for Secondary School Students, conducted by the Committee on Secondary Education in Science of the A. A. A. S. The author was 16 years old and in the 11b class of the Lewis and Clark High School of Spokane, Washington.

Imagine, if you will, a creature without arms, legs or bones; possessing no liver, kidneys, stomach, or any other familiar organ; a creature without a voice, or the ability to hear. Give it a voracious appetite, make it nearly transparent, and reduce it in size until two hundred of your make-believe animals put end to end would only make a line an inch in length. Then you will have a crude, but nevertheless fairly accurate, idea of the appearance of one individual of a vast group of minute animals called by science the Protozoa, which means in Greek "first animals."

Of course they do not all look alike; to the contrary, they have a larger variety of forms than the animals with which we have been familiar all our lives. The Protozoa have more weird and bizarre shapes than any other group of animals of which I have any knowledge. Some have beautiful shells, like tiny palaces, in which they live; many look like minute plants, and some have no more form than a mass of gelatin.

Many, many books have been written about these little creatures, but the methods of presentation are highly technical and are of no interest to one who does not wish to wade through such words as chrondriasomes, chromosomes, macronuclii and Golgi bodies. The purpose of this essay is to show what great importance is attached to this seemingly insignificant branch of the animal kingdom; but I hope that it also may be instrumental in explaining something of the actual lives of the protozoans.

Even now I distinctly remember what I saw the first time I obtained a glimpse through the eyepiece of a compound microscope.

Before me was a circular field of pale yellow light, a field so large that it strained my eye muscles to look from one side to the other of it. Floating in the middle of this circle of light were two large clumps of debris which are rather hard to describe to any one who has never studied the Protozoa. Photographs and drawings give the best impression of this microscopic debris. It is composed of tiny bits of water plants, algae, and innumerable other microscopic organisms, mostly plants. This debris forms the background of the microscopic field of vision. I have often heard it spoken of as "goo," a name which adequately describes it.

Scattered around haphazardly were little irregular pieces of a hard transparent substance that looked very much like bits of broken glass under water. I later learned that they were pieces of quartz, so small as to be perfectly transparent. But the main things that attracted my attention were tiny torpedoes, some transparent, some brown, and some partially green, and others with their sides covered with diagonal markings. Still others were curved like tiny boomerangs.

The most astonishing thing about it all was that some of these little torpedoes were moving! Captivated, I watched them move backward and forward, watched them bump into each other and push mightily through giant piles of debris. Their plowing to and fro reminded me of the movement of cruisers and battleships. Finally, something happened that turned all my thoughts in one direction, caused all my interest in the Protozoa,

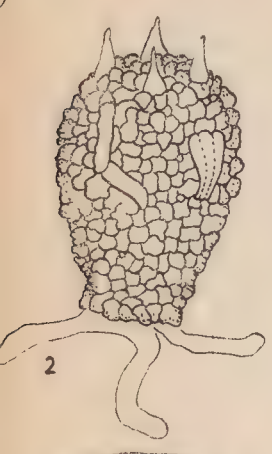
and, incidentally, resulted in the writing of this theme. From one corner of the brightly lighted field of view came a monster, thousands of times larger than the torpedoes that I had been watching. It came with incredible swiftness, extending halfway across my field of vision. In half a second it was in the center of the field of view, and although it was slightly out of focus I had a good view of it. Almost everything in view was obscured by its cigar-shaped body. As it passed through the field with an odd twisting motion, I saw on the outside of the semi-transparent body thousands of tiny hairs, which I later learned to call cilia, all in such rapid motion that to watch a single hair was next to impossible. In the center of the field the monster stopped, pivoted with all its cilia vibrating swiftly, and then disappeared out of the range of my vision close to the spot where it had appeared. Less than a second elapsed from the time when the ugly, cilia-covered snout appeared until it entirely vanished from my sight; yet the whole incident is burned deeply into my memory. This was my first acquaintance with a Protozoan, called by biologists *Parame cium caudatum* Although it resembled a monster from the Jurassic age, the Paramecium is very small; only one sixty-fourth of an inch in length.

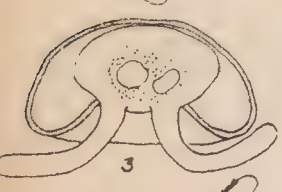
Two and one half centuries ago a Dutchman named Leeuwenhoek looked into the eye-piece of the first microscope ever invented, and discovered a new world that was totally undreamed of before this time. Since that day, countless experiments with that world's strange inhabitants have revealed to us a wealth of knowledge that has been of unending value to our race. It has made possible our biological and medical knowledge which, perhaps, has benefited man more physically, than any other thing. During the middle ages, thousands of people lost their lives in terrible plagues that swept Europe and Asia. Malaria, Bubonic Plague, Leprosy, and other loathsome diseases made the lives of the people miserable. In the New World, Yellow Fever, Chagas' disease, and other maladies that beset the people of the tropics took an enormous toll of human lives.

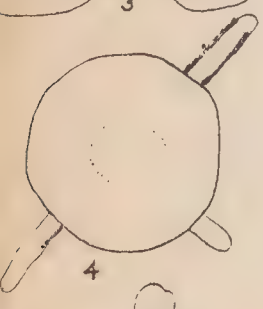
It has been only through the use of the microscope that scientists have been able to wipe out some of these dread diseases, for without this instrument, we could not have discovered their underlying causes. Although the majority of common diseases are caused by bacteria, the most horrible of them all result from the attacks of some of the members of that branch of the animal kingdom that I mentioned before, the Protozoa.

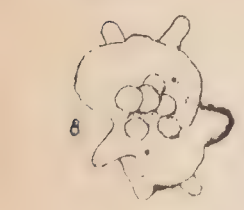
A Protozoan is a microscopic animal, usually consisting of a single cell, which lives its life in much the same manner as we, with our millions of cells, do. The Protozoan is, to the layman, an unbelievably small creature. Only the largest of the Protozoans are big enough to be picked up with forceps, some may be seen with the naked eye as moving white spots; but the majority are much too small to be seen in this manner, and some, scientists have reason to believe, are too small to be revealed by the most powerful microscope. Ask any person of average intelligence, but without biological instruction, what the Protozoa are, and the chances are ten to one that he does not know. He does not even dream of their existence.

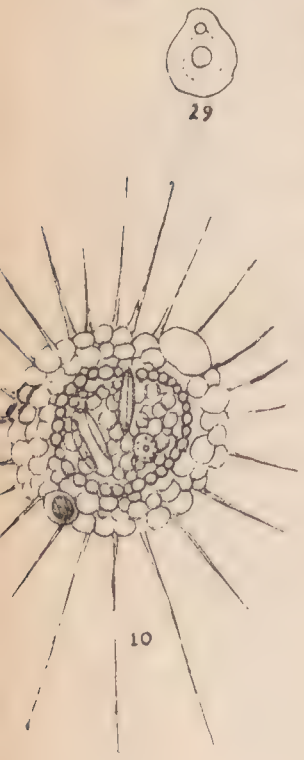
Of all the branches of the animal kingdom the Protozoa are the most simple. Our bodies, and the bodies of the common animals and plants, are composed of millions of tiny individual blocks of matter called cells. These cells are thus the fundamental unit of the organic world. Any cell in our bodies that is isolated from the rest immediately dies, for it is completely separated from the transportation system of the body, the blood. Since it thus loses all means of securing food, and has no emergency method of obtaining any, it is unable to live. Thus, the











highly organized cell is utterly dependent upon the other parts of the body for its very existence. But the protozoan is an independent cell. All the life processes of assimilation, respiration, excretion, absorption and reproduction are done within the walls of a tiny blob of matter, sometimes scarcely more than one three-thousandth of an inch in diameter. Some Protozoans obtain food through narrow buccal grooves that extend into the center of the cell, while others obtain it by the most simple method possible, that of absorbing it through the cell wall. Reproduction is accomplished by the simple method of dividing into two parts. Thus, these small, weird creatures of a world, unknown before the 18th century, live much as we do.

A well-known fact is that there are far more "plant like" animals than "animal-like" plants, but this does not hold exactly true among the Protozoa. Many of the animals are attached by stems in much the same manner as plants, while some of the plants, notable the diatoms, move nearly as freely as the animals. The tiny torpedoes that so astonished me when I first saw them are a species of moving diatoms. To make matters still more confusing some so-called "animals" *(Euglena veridis)* possess green coloring matter, a substance that, in the higher types of animal organisms, is utterly unknown. In fact, it is one of the sure ways to distinguish a plant from an animal in our world. But, in this tiny world of the microorganisms, all this is changed. Apparently, animals may be plants, and plants may be animals, absurd as it may seem. At the present date, there is much controversy over the matter, but I do not believe that the question will be solved soon, for it depends upon too many highly technical matters.

The Protozoa are divided into several different classes, which are distinguished from each other by their methods of locomotion. Some of the most simple in nature that have ever been seen, move slowly and sluggishly through the primal ooze in which they live, by an odd, flowing motion that strikingly resembles the movement of a bit of gelatin on an inclined plane. Their progress is often so slow that one must observe for several moments to see that they actually are alive and moving. The Amoeba, the most simple animal known, belongs to this class, appearing remarkably like an animated blob of jelly constantly searching for food.

Other Protozoa move by means of slender whips, so tiny that their width cannot be seen except with the most powerful instruments, while others, like the Paramecium, are covered with thousands of cilia. These cilia are of extreme importance to the protozoan because, by their aid it obtains food by producing currents toward its mouth. The protozoan is able to move rapidly by using the cilia as tiny oars to beat the liquid in which it lives. Because of these cilia, this class of Protozoa is called the Ciliata.

Another class, the most interesting to me, is called the Mastigophora. Literally, this means "Whip bearers" a name which exactly fits them. They are called this because of the long flagellum or whip that extends in front of them. By a peculiar motion of this whip, they are enabled to move slowly and sedately through the water in which they pass their existence, pushing steadily through masses of debris, always feeling out their pathway with that tiny whip.

Trying to figure out the personality of a certain protozoan is much fun. They have as widely different manners and habits as the people with whom we are associated every day.

Some of the Protozoans are so slow thinking that it is a wonder that they are alive at all. They will lie passively on the bottom of a glass slide, while other tiny organisms bump into them, crawl around them, and I have even seen an instance where a smaller Protozoan tried to crawl under his superior enemy. Good

food lies literally "at its elbow," but it does not sense it. I know of some people who act in much the same manner.

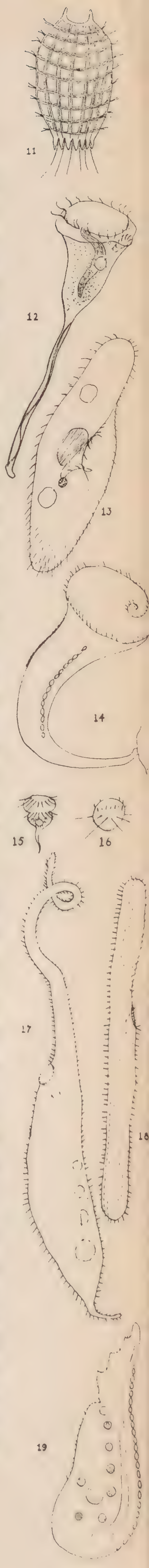
On the other hand, some microorganisms are so sensitive and swift that even the slightest movement of the slide will send them darting off at such speed that their form is indistinguishable. The peculiar thing about them is the fact that they seem to be able to attain full speed from a dead stop almost instantaneously. No vehicle made by human hands is this efficient. Since they are ready to dash away at any moment they are disturbed, they remind me of hundred-yard sprinters ready for action.

Several other species of Protozoa may be classed as nervous old ladies, the type that jump out of their seats almost to the ceiling when they are frightened. The ones I have in mind are Vorticella and Stylonichia. Vorticella is one of the fixed Protozoans, that is, it is attached to an anchorage by a long retractile stalk. If it is frightened, it immediately yanks its stalk into a closely coiled spiral. It can do this so fast that it is merely a blur shooting backwards from its original position.

One thing in particular amuses me; that is the behavior of a crowd of Paramecia. They do not seem to behave with any better manners than a crowd of people at a parade. When there are hundreds of them packed in a space scarcely one half an inch square, they act up in the usual manner of crowded individuals. They butt their blunt "noses" into each other, roll over and over, and, in general, behave in the most undignified manner. One Paramecium will race along at full speed, run full tilt into the stern of another slower than he, turn with a swift rolling motion, reverse gears, and back squarely into a strand of algae, scattering a group of bacteria with the powerful water currents caused by his impact with the strand. Around every air bubble imprisoned between slide and cover glass are vast crowds of Paramecia and every other ciliate that can crowd its way there, all trying to obtain the necessary oxygen. If one considers them crowded in the open spaces under the cover glass, they are swarming around the air bubbles. They are so close together that there is hardly any room for their cilia to beat the water without striking against a neighbor. Around and around they swirl, sliding over and over each other, backing, twisting, turning, and skidding. If any of them are hungry, it is practically sure death for a bacterium to venture into that maelstrom of flashing cilia and gaping buccal groves. This crowding around air bubbles for the necessary supply of oxygen is called "positive chemitropism" but to me it seems to be very akin to pure greediness.

The microscopic world is far from being a peaceful place. It is a place where cannibalism is the style and where brutalism is the custom. Fortunately, the inhabitants have no voices or else a most horrible, though faint, medley of shrieks, groans, and cries of mortal anguish would arise from every pool of stagnant water.

Apparently peaceful Protozoans lying on the bottom are, in actuality, whipping up the water with a ring of cilia which pull smaller organisms mercilessly into their gullets. Some of the ciliates that are attached by stalks might look like pretty flowers were it not for the fact that in front of each one there is an area of swirling water. If a tiny wriggling bacterium comes too close to that whirlpool of death, it is whipped towards the creature's maw with such speed that it is difficult to follow its meteor-like flight. After that there is one less bacterium to propagate its kind. In fact, this tiny world is almost always a shambles, where the motto is eternally "the survival of the fittest." To the Protozoan it is either to eat or to be eaten and he does his level best to do the former. All these animals have to do in their short lives is to feed and reproduce, and this they do mightily. To fail in either means to be wiped out



of existence.

From my explanations one may gain the impression that the Protozoans are a group of animals that, as far as we are concerned, are as distant as the Andromeda galaxy, but such is not the case. One might draw the conclusion that, because of their small size the Protozoa must be difficult to find, and probably are not very abundant. This is emphatically not so. Their size does not detract from their importance, for they make up what they lack in size by their numbers. The abundance of the Protozoa is unbelievable. They outnumber all the other animals of this planet millions to one, swarming the seas from the surface to the greatest depths, from the North Pole to the South, and live in countless numbers in every lake, pond, stream, and puddle the world over.

The reason for this enormous distribution is this: Since the protoplasm of all living cells is largely composed of water, the loss of this water is fatal to the organism. Even animals which do not actually live in water cannot go for long without this vital necessity. Therefore, when the pond or stream in which a Protozoan is living dries up, it protects itself by enveloping in a hard protective sheath or cyst. As this cyst is very small, it is blown about at the mercy of the air currents until it once more regains its native habitat in some body of water. Here the cyst dissolves, and the Protozoan continues its usual existence. The main reason for the extensive distribution of the Protozoa is the fact that the cysts adhere to any substance with which they may come in contact. When a pond dries up in summer, the grass that soon grows to take its place is covered with billions of tiny cysts which stay there for a year, enduring the hardships of cold and drought until the spring rains once more create a pond on the site of the old one. In two weeks, this newly created pond is swarming with microscopic life.

Although the majority of the Protozoa carried by the wind are limited to some thirteen species, there are enough of these in our atmosphere to average two and one half cysts in every cubic millimeter of air, about the volume occupied by a pin head! The Protozoa are thus found the world over wherever there is sufficient moisture and where chemical and physical conditions are suitable for life.

The pathogenic or the disease producing Protozoans are nearly all parasites; most of them rarely living even for a brief interval of time in a nonparasitic form. After we have seen how thickly the Protozoa abound, it is no wonder that some of the higher types of animals cannot have helped taking some of the Protozoa into their digestive tracts. It is therefore not strange that certain Protozoans have adapted their lives, through millions of years, to the conditions of living in the juices of the alimentary canal, gradually developing a chemical structure which is immune to digestive enzymes. Some species may migrate to the blood and lymph, and others may take up their abode in the tissues. Thus, originally harmless Protozoa may, through constant association with certain forms of environment, become entirely parasitic. They may be likened to people who have desired a change of living conditions and have therefore found other homes. For a parasitic Protozoan to leave its host, unless suitably protected, is certain death, for it has moulded its life functions so closely around that of its host that the separation of the two would mean the loss of nourishment for the parasite, and death would immediately follow.

To discuss the effects of disease in a serious state of mind has always been repulsive to me, yet it must be done. It is on account of the dreadful maladies that they cause that the pathogenic Protozoa are so important. Even so it is an interesting subject—for some.

Malaria, Yellow Fever, and other highly pernicious diseases are caused by the

Sporozoa, a parasitic class of the Protozoa. Malaria itself is the best known and is also the most fatal malady. It alone has accounted for more than fifty per cent of all deaths caused by Protozoan disease. To another class, the Mastigophera, belong the trypanosomes and the spirochaetes, the latter being the cause of syphilis and yaws. The less said of them the better.

As all parasites behave in approximately the same manner, the life history of the trypanosomes will give an idea of the importance of the pathogenic Protozoans.

The trypanosome is a delicate, exceedingly active Protozoan belonging in the closs Mastigophera, its whip extending forward along its body through a loose undulating membrane.

Like some other parasites, the trypanosomes live only part of their lives in their various unfortunate victims, but unlike many others, they can exist, in a multitude of conditions. Not only do they attack human beings, but also monkeys, dogs, rodents, domestic animals, and African game animals. The last of these named do not seem to succumb to the life draining effects of the disease, but rather seem to be reservoirs for its distribution. Part of the trypanosome's life is spent in the intestinal tract of the tsetse, a fierce, blood-sucking fly that abounds along watercourses in some parts of Central, Eastern, and Southern Africa. Entering with the blood the digestive tract of the fly the trypanosome begins certain important changes, scientists are not certain just what, but soon the salivary glands of the fly are packed to overflowing with countless numbers of darting parasites, ready to leave with the first bite of the host into a new victim. In a human being, the trypanosomes at first wander through the blood stream, twisting and turning in and out among the millions of ever hurrying red corpuscles. Hundreds are probably killed by the scavengers of our blood stream, the phagocytes, but they multiply so rapidly that the efforts of the body to stop them is useless, unless it is given outside aid. In ever increasing numbers, the foe find their way to the lymph, the lymph nodes, the glands, the liver, kidneys, and finally; usually a few months, or even years after they were first introduced into the blood; they reach the cerebral fluid in the brain and spinal cord. At this stage, the victim becomes more and more drowsy, until he falls into a painless sleep from which there is no awakening.

This disease is the dreaded African sleeping sickness, and, next to Malaria, is one of the worst known. The whole destiny of Africa is hinged on the fight of medical men against this malady which has, in comparatively recent years, caused the deaths of hundreds of white people and thousands of negroes. In seven years, from 1901 till 1908, the population of one district in Central Africa was reduced from 300,000 to 100,000, and there are records of whole villages being wiped out of existence.

Along with the algae, the Protozoa cause a great deal of trouble in reservoirs for public water supply. The oils released from their bodies when they are pounded to pieces in pumps, valves, and pipes are not pleasant smelling in the least. The culprits are Protozoa that cannot stand brackish water, so they do their level best to wreck our water by getting into clean reservoirs. They bear the names *Uroglenopsis americana* and *Synura uvella*. These names are probably a great aid in scaring away enemies; but they do no good when the water is chemically treated, usually with copper sulfate.

In the sea, countless other protozoans, together with the one-celled plants, furnish food for larger organisms. These, in turn, feed still larger animals, until man himself receives his share. Our chalk beds were produced by the compression of billions of tiny shells made by Protozoars who lived in the seas of the Paleozoic era, five hundred million years ago. These are

some of the principal things of importance about the Protozoa, but there are still other things that are of extreme interest.

How I came to know something of these tiny creatures can be told very quickly. After my adventure with the Paramecium, my interest was so aroused that I purchased a tiny microscope that magnified an object sixty times its normal diameter. Compared with the instruments I later used, it was a 1914 Ford alongside a 1930 La Salle. The lighting effects were terrible, and too long observation temporarily wrecked my eyes; but it enabled me to satisfy my craving for knowledge of Protozoan life. By its aid, I obtained a tremendous head start over my later acquaintances in zoology. I was afraid that I would be left out without a "mike," for there were only five for a class of twenty-five, but when ten brand new microscopes were purchased, and when I learned that my teacher possessed a high powered, oil immersion microscope, I felt like turning several handsprings and doing the Highland Fling on the tops of the tables. Now I had, at last, a chance to realy study. For sixteen weeks after that I worked every chance that I could obtain observing, drawing, and experimenting. By this method I slowly built up my knowledge of the protozoan world.

Four thousand years ago, skilled surgeons and physicians of the Egyptian court practiced their profession with instruments that closely resemble those that are used today, but they depended upon their own "black magic" to cure their patients. What an aid the microscope would have been then.

How can we help wondering why we did not learn of these things about the Protozoa centuries ago when that knowledge would have been of tremendous aid to mankind? It is simply explained by the fact that, in ancient times, the theory of Guessing outshone the theory of Experimentation. For only two hundred years have we emerged from the darkness that surrounded the doctrine of biology and health for so many generations, but now we are at last coming into the light.

REFERENCES

1. Calkins. Biology of the Protozoa.
2. Ward and Whipple. Fresh Water Biology.
3. Chandler, Asa. Animal Parasites and Human Disease.

President Hungate announces that he has secured Dr. George Finlay Simmons, President of the University of Montana at Missoula, for the main speaker at the general sessions of the Annual Meeting of Northwest Scientific Association, December 2 9and 30, 1936. Those who read the brief sketch of Dr. Finlay's life in the May issue of Northwest Science will recall the variety of his interests and activities and anticipate very interesting sessions. His subject for the general session of the morning of December 29 will be "The Mechanics of Reproductive Periodicity in Mammals" and at the luncheon with the Associated Engineers of Spokane on the 30th will be "A Windjammer Voyage to Treasure Island."

At the annual dinner on the evening of December 29, Mr. W. A. Rockie will give the "Retiring President's Address," speaking on some phase of soil conservation.

Recipients of grants of last year for aid of research, Drs. H. P. Klug, G. A. Matson and J. H. Ramskill, will report progress of their subjects.

E. M. Keyser, Chairman of the Board of Trustees, reports contributions to the Howard R. Flint Memorial Fund are coming in sufficient to encourage those who have been active in promoting this means of supporting scientific research in this region.

Two Prize Winning Essays

A national scientific contest for students of secondary schools was held in 1930 by a committee on secondary education of the American Association for Advancement of Science. Two students of the Lewis and Clark High School, Spokane, entered this contest and won third and sixth rank. They are here published for the first time.

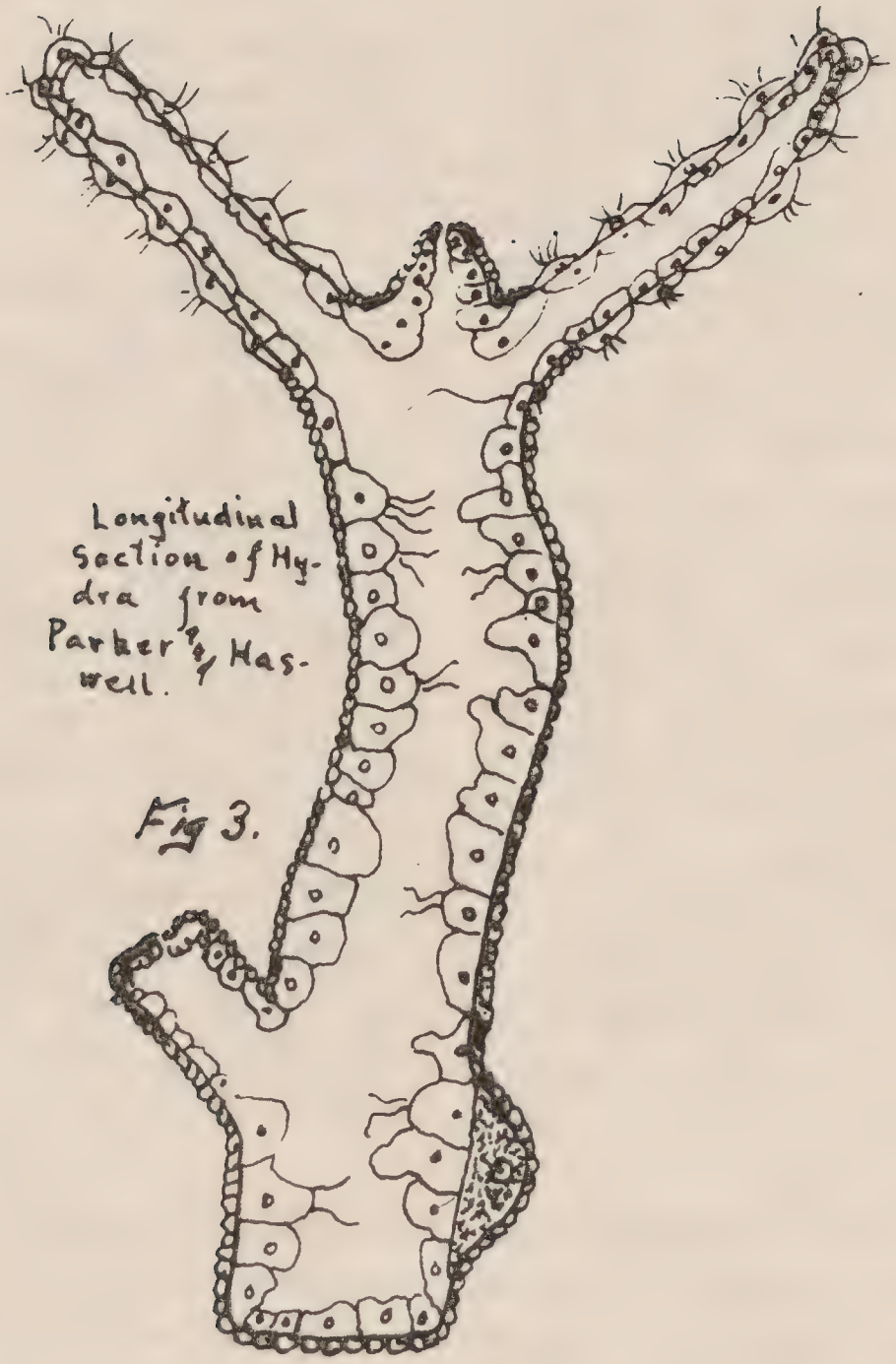
Several motives underlie the publication in this issue of Northwest Science of these essays by Ralph Lawrence and Dunbar Triplett. (a) Students were told on entering this contest that winning essays would be published. (b) Both essays indicate the effect on the student of direct study of the living animals with a minimum of teacher intervention or text-book assignment. (c) Both are free from injected theoretical matter and derive their interest from the material studied. (d) They represent the work of two different types of student: one, a young boy just beginning the second year of high school, somewhat resentful of a good deal of the high school work, including the study of zoology, and who disliked his English. His "experiments with Hydra" were done at home and were influenced far more by his earlier experience with a "chemical set" than by any teacher influence. What influence the zoology teacher's ideas had on him was negligible, except the suggestion that he keep records of the unusual things he was doing with Hydra at home. The teacher in charge of the essay contest for the school did little more than keep him encouraged. To the English teacher he is indebted for aid in putting the essay in form. It became for the period, his class work in English composition. Many a more mature scientist has used as much help and many others would profit if they did. The other essay was by a boy whose zoology classwork was seen in retrospect. He had completed the study in high school the previous year. Both are now preparing at Washington State College for life careers in chemistry.

STATEMENT FROM THE A. A. A. S. COMMITTEE ON SECONDARY EDUCATION IN SCIENCE

"In approving the publication of the essays prepared by Ralph Lawrence and Dunbar Triplett I wish to express the appreciation of the entire committee of the fine quality of work presented by these students. Such essays have stimulated a large number of students and have resulted in an increased interest in science. In fact, the essays in general are an evidence of a previous interest in science which has found a means of expression through the papers prepared by the authors."

OTIS W. CALDWELL,
Chairman of A. A. A. S. Committee for Essay Contest for Students of Secondary Schools, General Secretary A. A. A. S.

Marginal illustrations accompanying the article on Protozoa are of twenty-seven comman Protozoans of the Spokane region. They are furnished by Ruth Fisken Large and Thomas Large. The following numbers may assist in recognition of these forms: 1. Difflugia sp.? 2. Difflugia corona. 3. Arcella vulgaris (in section). 4. Arcella Vulgaris. 5. Amoeba proteus. 6. Amoeba verrucosa. 8 and 9. Entamoeba gingivalis. 29. Amoeba guttula. 10. Actinosphraereum eichornii. 11. Coleps hirtus. 12. Vorticella. 13. Paramecium. 14. Stentor polymorphus. 15. Urocentrum turbo. 16. Halteria. 17. Dileptus gigas. 18. Spirostomum ambiguum. 19. Loxophyllum (?) meleagris (?). 20. Trypanosome. 30. Euglena. 21. Paranema. 22. Astasia. 23. Dinobryon. 24. Synura uvella. 25. Pandorina morum. 26. Same reproducing. 27. Eudorina. 28. Volvox.



Longitudinal Section of Hydra from Parker & Haswell.

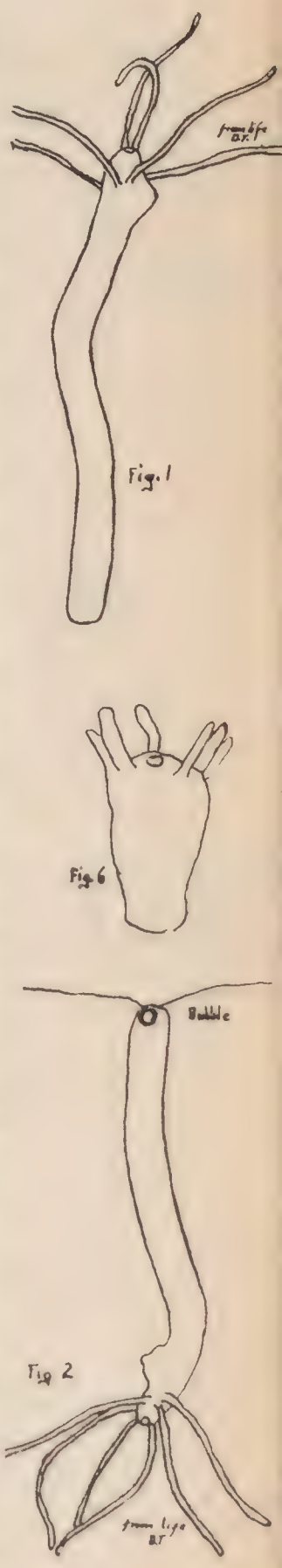
Fig 3.

My Experiments With Hydra

By DUNBAR TRIPLETT, JR.

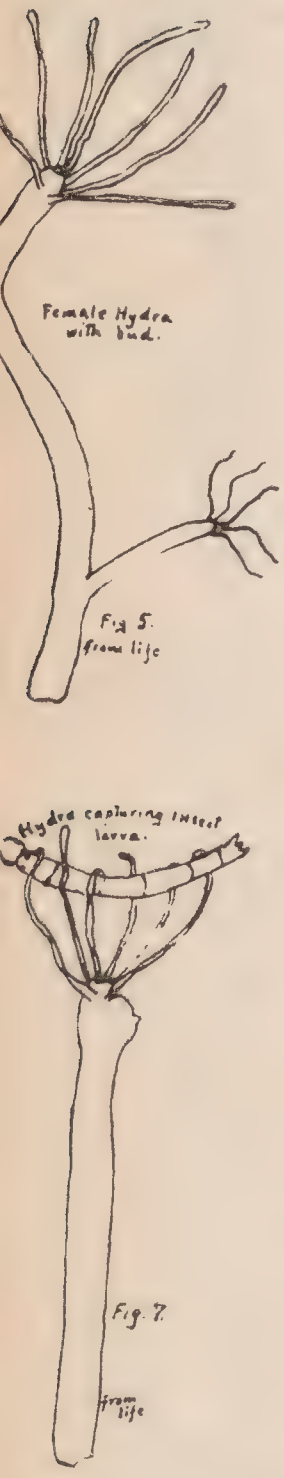
This essay was given sixth rank in the National Scientific Essay Contest for Secondary School Students, conducted by the Committee on Secondary Education in Science of the A. A. A. S. The author was 15 years old and in the 10b class of the Lewis and Clark High School of Spokane, Washington.

When I skated over the smooth, glassy ice of the pond at Cannon Hill Park last winter, I never dreamed of the vast universe that lay beneath me. That pond is more than a universe, for it would be almost impossible to estimate the millions of the Protozoa and minute organisms which are in it. There are probably more tiny creatures in that pool than there are people in the world. The water is also quite abundant with Hydra. I had never even heard of a Hydra until my Zoology instructor asked everyone to bring from certain swamps in this vicinity water that we might examine. About a week before that time I had brought in a jar of water from this pond, which happens to be near my house, to see what was in it. A few days later the instructor informed me that a boy had found several Hydra in the water. I immediately rushed up to the pond and took home two bottles of the desired water to examine it for Hydra. I got out my magnifying glass and revolved one of the jars, looking carefully all the while for the tiny animals. I found none. With great disappointment I put the bottles away, intending to throw the water out as soon as I had time. About two weeks later I remembered the jars of water in my closet, so I went to dispose of them. They had made the whole closet smell like a sewer. Picking them up, I noticed that one seemed to be covered on the inside with little green dots. On looking more closely I discovered that the green specks were Hydra. I hurriedly got out my microscope to get a close view of one. My first glance at a Hydra gave me the impression that I was looking at an octopus. It would stretch itself out to a terrible length, so it seemed under the microscope, waving its tentacles majestically back and forth. Then quite suddenly it would contract until it looked like a carrot, and its tentacles like tiny dots. It was from one-fourth to one-half inch long when it extended, and about one-sixteenth of an inch when contracted. It was as big around as a needle. (See figure 1.)



According to color, there are three species of Hydra; namely, green, brown, and gray. Green Hydra are the most common species around Spokane. Brown are next, and I doubt if any gray at all have been found in this vicinity. The green Hydra are really dual organisms. It is generally believed that the greenish corpuscles in the inner layer of the animal are partner algae which are very helpful to the Hydra because they liberate oxygen and build up carbohydrates. They are used in the same way as chlorophyll is in a plant. If Hydra is kept in the dark and liberates a sperm cell or egg at that time, the egg will develop into a white Hydra. This fact implies that the partner algae did not migrate into the egg and shows that sunlight is necessary for these algae to migrate. In other species of Hydra the pigment is quite different from chlorophyll. I think that the green Hydra use the oxygen formed by the algae to keep themselves at the surface of the water. One day I found, in my jars, a number of the Hydra hanging from the surface of the water by their basal ends. I took one out with a medicine dropper and put it on a slide for examination. On the very tip of the Hydra was a tiny bubble of some kind of gas. (See figure 2.)

I believe that this gas is oxygen, and I intend to test it some time to see if I am right. As far as I have been able to discover from inquiry and reading, no one has yet mentioned anything of this bubble, so I think that I have an entirely new theory.



Hydra are also classified according to sex. There are two types. The first embodies both sexes in one individual. The second type has the male and female separate. In the first type the spermary of a Hydra liberates sperms which are received by the ovary of the same Hydra, or perchance, by another individual. The spermary of a male is merely a group of sperms bounded by the distended ectoderm. The ovum of a female is one successful cell in the center of the ovary. (See figure 3.)

It is first amoeboid, but soon grows richer, drawing from the cells around it. With the increase in size it becomes cake-like, and from that stage goes to a spherical form. Around the spherical ovary a gelatinous sheath is formed. (See figure 3.) When the ovary is fully grown the ectoderm of the parent Hydra ruptures, allowing it to protrude. (See figure 3.) In this state it is fertilized, the sperm entering at the distal pole, which is an opening in the ovary.

The segmentation which then takes place results in a blastula and an endoderm is formed. The bud remains on the parent until it is fully formed. It forms a mouth at the distal end by rupture, (see figure 3) then separates, and the process is repeated. In the brown Hydra the egg is separated before a shell is formed, and is fastened to water plants by its gelatine covering. In another type, the egg drops off as soon as the outer shell has been formed. Hydra are very pretty when they have buds, as they look like minute green water plants. (See figure 5.)

The study of the feeding and digestive process of the Hydra is very interesting. It extends itself to full length and slowly rocks back and forth, waiting for some unsuspecting larva, Cypris, or some other minute creature to swim into its tentacles. Occasionally, if there is a slight disturbance, it will contract. (See figure 6.) Soon a tiny Cypris swims into one of the tentacles, releasing a sting. (See figure 7.) The Cypris is paralyzed by the poison, and the Hydra has a fine meal without any trouble. The tentacles of a Hydra are covered with trichocysts, or sting cells. These sting cells are rather oval in shape, but at the tip come to a curved point. This curved point is called the trigger. When undischarged, the lasso is coiled up within the cell. The least touch of the trigger will release it. (See figures 8 and 9.) The tip of this lasso is filled with poison, and when the lasso is released it entangles the prey, which is paralyzed by the poison. The trichocyst is like any ordinary cell and has a nucleus and cytoplasm. It also has a fluid-containing cavity in which the lasso lies coiled. Because of their sting, Hydra are not eaten by fish. After the food has been captured, the tentacles bring it within reach of the mouth. The flagella (see figure 3) which protrude from some of the endoderm cells gently waft the food into the body cavity, where it is digested by the amoeboid cells. The cells that line the body cavity and form the endoderm are of two kinds. The cells of the first type have one or more flagella protruding from them. The cells are usually regular in shape. Those of the second type are called the amoeboid cells. They are the cells which digest the food, but have no flagella.

There are four steps in the cell cycle. The first is the encysted step. Following that, the cell breaks into spores. The next two steps are illustrated in the endoderm of a Hydra. The third step is the escape of the spores. They are first in a flagellate state, and then go into the amoeboid state, where they feed, and start the process all over again. The amoeboid cells are all very irregular in shape. The hollow space inside the Hydra just below the mouth, and where the tentacles branch off, is called the enteric cavity. (See figure 3). The whole body, including the tentacles, is hollow, so the food is evenly distributed even to the ends of the tentacles. The indigestible matter is then ejected through the same opening by which it

entered. Around the mouth are several glandular cells, which some observers record as having sting cells, although it is thought that these were nematocysts which were drawn in with the food. A Hydra is able to kill and eat creatures many times its own size. I once saw a May Fly nymph swim into a Hydra. The Hydra immediately took hold of the nymph, but was torn from its place on the side of the container. The nymph, being much larger than the Hydra, swam all over the jar with it. After stinging the larger creature to death, the Hydra finally won out.

The cells of a Hydra are very queer, in that they will form new Hydra if one is bisected. One day I decided I would experiment so I selected a large Hydra, drew him up in the dropper, and placed him on a clean slide with very little water. I took a pin and drew the drop of water out into a line about an inch long. The Hydra slowly extended itself along the water. When he had stretched to full length, I took a very sharp razor and sliced him into two parts. I then set those two parts aside in a test tube where there were no other Hydra. When I came home from school the next day the distal end, of the bisected section of the Hydra, was entirely regrown and the basal end had developed a set of tentacles and formed a spermary. I thought I had discovered something entirely new, until on inquiry I found that the experiment had been performed with the same results, about two hundred and fifty years ago by Abraham Trembley, an English tutor. At that time though, Trembley could not determine whether a Hydra was a plant or an animal. When it grew tentacles after he had bisected it, he decided that it was a plant; and then, seeing it move, he thought that it was an animal. Another day when he discovered one with a bud he again thought it to be a plant. Right after that he saw one liberating a sperm cell and his theory changed once more. Finally in desperation he sent some specimens to Reaumur, a great physicist friend of his. Reaumur at once declared them to be animals, and proposed the name polyp, which was originally applied to Cuttlefish. Linnaeus afterwards suggested the name Hydra, recalling the mythical monster with which Hercules battled. Every time Hercules cut off one of the arms of this monster another grew in its place. If one is cut into several pieces, each part will re-form if it has favorable conditions. There is a quantitative and qualitative limit, though. There must be a sample of all the different kinds of cells in that piece. The Hydra is nowadays recognized everywhere as an animal. It belongs to the great Coelenterate group of which the jellyfish and sea anemones are members. It is also related to the sponge and is quite similar except that the sponge has a different feeding process. It takes its food through tiny holes in its sides and gets rid of indigestible material through a hole in the center of its group of tentacles. While Trembley was really the discoverer of Hydra, he was not the first man to observe one. Leeuwenhoek, an eccentric Dutch observer, saw some in 1702. That was the period when microscopes were being invented, and not many men could afford to have a good high-powered one. Leeuwenhoek was one of the best lens makers of his day and had a number of wonderful microscopes. He wrote to the Royal Academy in London about the Hydra but nothing more was done at that time.

Hydra has a very queer life and stays in one place a long time. When it moves it does it by looping like a caterpillar, and throwing out sting cells by which it holds on to plants. The nervous system of a Hydra is like a network and goes to all parts of the body. The average life of one of these animals is two years. They have periodic depressions which last for two or three weeks, during which time the Hydra contracts, does not eat, loses his hold, and falls to the bottom of the pond. After this period he resumes normal

life. Each depression is more serious than the preceding, until finally one is fatal. They must also have good living conditions. When I took some Hydra and put them into a test tube full of water from the city main, they soon died. I put some others in a test tube but I also put in some Cypris. They are still living. It is easy to tell whether a colony of Hydra is getting enough food or not. If there is not much food there will be a great many males and few females. If there is plenty of food there will be more females. Daphne pulex, or the water flea, is the favorite food of the Hydra.

I think that Zoology is a very interesting subject, and should arouse everyone's interest. I was always bored by the idea of looking through a microscope until I took this subject. In the basement of our house I have a chemical laboratory, where I experiment a great deal. Now I have added a microscope to my equipment and am interesting my friends in Zoology as well as Chemistry.

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Spruce in the Western Miocene

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One of the real surprises in store for us as we began to section specimens of petrified wood from the Vantage and certain other horizons in Central Washington, was the prevalence of a spruce type hardly hinted at in the leaf lists as published for the various sediments of Yakima time (upper miocene?).[1]

Influenced by the redwood and redwood border forests which Dr. Chaney has reconstructed for the Mid-Tertiary of this general region,[2] we felt obligated to exhaust all possibility of putting many or most of these generalized spruce woods, Pieceoxylon to the paleobotanist, into the modern genus Pseudotsuga (Douglas fir). This effort has at length been abandoned and we are now in a position to contend that most of the logs involved are in fact spruce (Picea), that a small fraction of them undoubtedly represent tamarack (Larix) and that an insignificant per cent at best can be referred to the genus Pseudotsuga (Douglas fir). To support this virtual exclusion of the Douglas fir we point to the consistent absence of spirals in even the best preserved specimens, although ghost spirals such as occur in the tamarack are found in certain reddish woods. In given horizons such as the Vantage, spruce types attain a dominance approaching fifty per cent, and one is immediately challenged to defend his determination of this genus in the face of the spruce-less leaf lists of the older paleobotanists.

In view of this unsuspected dominant spruce element and other discrepancies the question arises as to the advisability of including the Latah or any strictly Yakima flora (whether based upon foliage or wood) in Dr. Chaney's Mascall flora.[3] When Dr. Chaney described this flora as of oak-madroño character, a forest type now found along the redwood borders of California, no one had conceived of the lowland swamp forests which succeeded each other out upon the monotonously flat lava flows of the Yakima series, nor had there been visualized the somewhat different swamp and lowland forests which undoubtedly followed the old established water courses up into the hinterland. It seems necessary, therefore, to revise and enlarge upon Dr. Chaney's Mascall type forest or to deny its wipespread application to the Pacific Coast Inland Basin.

Comparing, as best we may, our Ginkgo series of dominant genera with those of Dr. Chaney's Mascall we obtain a negative result with the implication that any forest of strictly Mascall character in Central Washington during Yakima time must have confined itself to higher altitudes. On page 35 Dr. Chaney lists eleven types as dominant in the Mascall flora. We give them in his order of dominance with the number following indicating the rank we can allow each in our Ginkgo forests. Following is a list of the dominant Ginkgo genera with Dr. Chaney's Mascall standing included.[4]

MASCALL FOREST	
1. Umbellularia (California laurel	0
2. Platanus (sycamore)	11
3. Ulmus (elm)	3
4. Sequoia (redwood)	8
5. Aesculus (buckeye)	0
6. Alnus (alder)	0
7. Populus (cottonwood)	0
8. Juglans (walnut)	5
9. Quercus (oak)	4
10. Acer (maple)	7
11. Pasania (?) (tanbark oak) (?)	0(?)

GINKGO FORESTS	
1. Picea (spruce)	0
2. Taxodium (swamp cypress)	0
3. Ulmus (elm)	3
4. Quercus (red and white oak)	9
5. Juglans (walnut)	8
6. Liquidam (red gum)	0
7. Acer (maple)	10
8. Sequoia (redwood)	4
9. Nyssa (tupelo)	0
10. Fraxinus (ash)	0
11. Platanus (sycamore)	2

As for the four last types in our petrified forest list there remains the possibility that several exotic trees deserve recognition in a list of eleven dominants. At least there is no certainty of numerical dominance beyond the first seven in the list.

It is not our argument that the Ginkgo types above occur together in a restricted forest community. In fact the petrified spruces and swamp cypresses rarely occur in immediate proximity, as for instance in the Honson, a prostrate forest, an assemblage otherwise anomalous in that elm gives way to sycamore as a conspicuous element and red gum enjoys a marked dominance among the hardwoods. There is no assurance in a prostrate forest that the various included logs have been rafted in from and identical altitude or setting.

Once we had accepted spruce as a dominant member of our Ginkgo series of forests we were ready to consider the circumstances under which it may have flourished. Our attention was first given to the spruce as a high altitude element in company with such other conifers as hemlock, fir and pine. This possibility was given up when careful search yielded but the merest traces of the three other conifers named.

After recognition of the "pillow lavas" in which the logs are consistently buried,[5] we were well on the way to accept the spruce as a swamp element. Further, it became necessary to review all so-called redwood specimens and demonstrate that each was not in fact swamp cypress—the foliage and woods of these two fossils are with extreme difficulty to be separated. Finally we have come to the conclusion that the dominant logs in the Ginkgo series represent swamp and lowland types exclusively, and that this characteristic is reflected in certain of the associated leaf beds.

It will simplify our problem to divide the original habitats of these dominant petrified logs into three distinct areas. (1) Shallow overflowing lakes which outlining various stream courses nourished and knew typical Taxodium swamps. With this southern low altitude tree occurred such familiar associates as white cedar, tupelo, water ash, etc. (2) Low gradient partially dammed (by lava) courses of these same streams supporting above the lava level such swamp trees as spruce, tamarack, soft maple, red gum, white and red oak. (3) Rich lowlands back into

the old pre-Yakima land surface presenting to each annual flood such stream border types as elm, walnut, maple, red and white oak. The net product of these three areas was an assemblage of rooted border trees and open water rafts which waited in the ephemeral lava lakes of the period for the next volcanic outburst. Here conditions were favorable for their entombment and petrifaction.

One interior, swamp leaf bed has been discovered in the Vantage area—in fact, it lies immediately beneath the Vantage assemblage of logs. Its apparent contrast with the Vantage logs is certainly influenced by the fact that the overlying logs are derived almost exclusively from zones two and three as outlined above. Several marginal lakes, by which we mean beds of sedimentation along the border of the Columbian (Yakima) lava flows, have been studied. Among these are the Latah,[6] Grand Coulee,[7] Idaho[8] and several floras in Kittitas county which we have recently encountered. Several leaf beds promise to yield additional information relative to the more upland forests of Yakima or near Yakima time: The Eagle Creek Flora,[9] the Ellensburg Flora[10] and a new "Kittitas" bed. We reserve discussion of these floras for a future paper.

In line with the acceptance of spruce as a swamp element in the Pacific Northwest Miocene is its consistent occurrence in all suites of Tertiary fossil woods which have come to my attention. No conifer is more consistently associated with such types as Taxodium and cedar in what seems to be quite generally swamp assemblages, including the Eocene coal bearing horizons. Of special significance is the prevalence of spruce in the Chehalis woods quite certainly derived from early Tertiary volcanics. Here the hardwood associates are anything but familiar American trees. This "petrified forest" contains many elements of interest and will be discussed at length in the future.

In summary, evidence gathered in the petrified forests of Central Washington is conclusive that the spruce was a conspicuous member of low altitude lowland and swamp forests in Yakima time. With it occurred dominant genera now characteristic of the Atlantic section of North America and a wide range of subdominant types now found elsewhere in the Northern Hemisphere. It is likely that the spruce flourished in areas outside the Yakima region and throughout a larger portion of Tertiary time.

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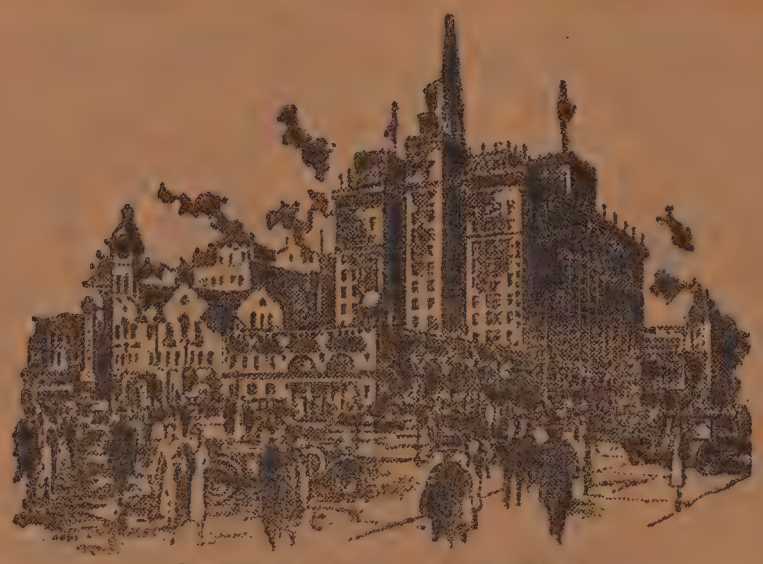

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